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State of Connecticut
State Geological and Natural History Survey
BULLETIN No. 24

TRIASSIC LIFE
OF THE
CONNECTICUT VALLEY

By
RICHARD SWANN LULL, Ph.D.
Professor of Vertebrate Paleontology in Yale University

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TRIASSIC LIFE
OF THE
CONNECTICUT VALLEY

BY

RICHARD SWANN LULL, Ph. D.

Professor of Vertebrate Paleontology in Yale University

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FOREWORD

The following dissertation has been prepared in compliance with a request from Professor William North Rice, and has resulted in as exhaustive a study as possible, not only of the terrestrial vertebrates themselves, but of the environmental conditions, both physical and organic, which governed their mode of life. The field of research necessarily included the entire environmental unit, the Connecticut valley, even though the work was prepared under the auspices of the Connecticut Geological and Natural History Survey; and only serves to emphasize the necessity of similar correlated investigations of the other areas of Newark deposition.

The selected list of works given in the bibliography were all used in varying degree; but I wish especially to acknowledge my indebtedness to the Hitchcocks, father and son, to Professors Marsh of Yale, von Huene of Tübingen, Emerson of Amherst, Rice of Wesleyan, and to my colleagues, Professors Schuchert and Barrell. Miss Clara LeVene, librarian of the Peabody Museum, has painstakingly prepared the manuscript for the press, while Mrs. Lull has aided very materially in the preparing of the illustrations.

Acknowledgments for permission to reproduce illustrations and for the loan of electrotypes are due to the American Museum of Natural History, through Doctor W. D. Matthew, to the Boston Society of Natural History, through Doctor Glover M. Allen, and to the Peabody Museum of Yale University, through Professor Charles Schuchert. From the American Museum of Natural History were received Plates iii, ix; from the Boston Society of Natural History, Figures 33, 34, 38, 39, 40, 41, 42, 43, 46, 48, 49, 50, 51, 53, 54, 55, 56, 57, 61, 62, 63, 64, 65, 68, 69, 70, 71, 73; and from the Peabody Museum of Yale University, Plates i, vii, viii, xi, Figures 9, 10, 15, 17, 18, 19, 20, 21, 24, 25, 26, 28, 29, 30, 126.

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INTRODUCTION

One of the most interesting chapters of the earth's past history is that of the time when there were laid down the Triassic strata of the famed Connecticut valley, interesting in the profusion of its indicated life, and fascinating in the baffling obscurity which shrouds most of its former denizens, the only records of whose existence are " footprints on the sands of time."

It is not surprising, therefore, that geologists should have turned to the collecting and deciphering of such records with zeal; nor is it to be marveled at that, after the exhaustive researches of the late President Edward Hitchcock, workers should have been attracted to other more productive fields, leaving the footprints aside as relics of little moment compared with the wonderful discoveries in the great unknown west.

HISTORICAL SKETCH

Except for small summary papers by Professor Charles H. Hitchcock containing descriptions of some new species, and occasional papers by other authors, nothing was done from the time of the publication of Edward Hitchcock's notable " Ichnology of New England " in 1858, and the Supplement to it in 1865, until 1904, when a new study of the tracks in the light of recent paleontology was published by the present author.[1]

Skeletal remains which were brought to light from time to time were described mainly by Professor Marsh in the *American Journal of Science,* and by E. Hitchcock, Jr. (1865), and Cope (1869) ; and later summarized by Marsh in " Dinosaurs of North America " (1896 B).

A final, more exhaustive study of the skeletal remains was made by Professor Friedrich von Huene in his " Dinosaurier der aussereuropaeischen Trias." No serious attempt, however, has ever been made to reconstruct the physical conditions of the Trias and to repeople the Connecticut lands of that time with their living, breathing, strenuous inhabitants.

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[1] Lull 1904 A.

The purpose of this essay, therefore, is to restore the environment, both physiographic and climatic, to clothe it with its proper vegetation and to discuss as fully as may be the animal life of that distant day.

One of the most remarkable features of the fossil remains of the Connecticut valley is the dearth of actual bones and the marvelous abundance of footprints — conditions exactly the reverse of those found in other fossil fields, for, outside the Triassic of New England and New Jersey, footprints are rarely met with, whereas bones in some localities are nearly as numerous as in the Valley of Dry Bones, the vision of which was vouchsafed to Ezekiel. Somewhat similar conditions to those in the Connecticut valley seem to prevail in the Southwest and elsewhere, but in no other known locality is the profusion of footprints so great. In spite of this, the discovery of bones in 1818 preceded a scientific appreciation of the tracks by nearly a score of years, though doubtless the latter were often seen by observers like Pliny Moody in 1802, who failed to realize their great significance. The reference of one to the footprint of "Noah's raven" is probably only one of many similar interpretations in the folklore of the Connecticut valley.

The profusion of species of animals represented by the tracks, which of course include the creatures the skeletons of which are known, is, so far as my present knowledge goes, as great if not greater than that of any other known vertebrate fauna of prehistoric times, and emphasizes once more the usual incompleteness of our geological record and the countless multitude of creatures which peopled our globe in the more remote ages.

PART I. THE TRIASSIC FORMATION

The Connecticut Valley

The rocks of the Newark system, which include the fossils under consideration, occupy a number of areas along the eastern coast of North America, of which the best-known are that of the far-famed Connecticut valley, and the adjacent one stretching from New York, through New Jersey, Pennsylvania, and Maryland into Virginia.

EXTENT OF TRIASSIC TROUGH

The Connecticut valley area, extending as it does across the states of Massachusetts and Connecticut, follows in general the depression now occupied by the Connecticut river, except in its lower course where the river forsakes the ancient valley at Middletown, and cuts its way through the Eastern Highland, reaching Long Island sound far to the eastward. The length of the Triassic trough is about 110 miles, from the village of Northfield, Massachusetts, on the north, to New Haven bay on the south. Its width varies, but averages some 18 miles, the total area being not far from 2000 square miles.

This Triassic depression is bounded on either hand by elevations of more ancient crystalline rock none of which is younger than the Paleozoic, and the weathering of which constituted the source of the Triassic sediments.

AGE AND GEOLOGICAL HISTORY

Eastman (1913, p. 23) tells us that the best authorities have placed the Triassic rocks of eastern North America in the uppermost division of the Triassic system, that which in European geology is called the Keuper. This opinion has rested hitherto almost exclusively upon the evidence of paleobotany. He says:

"Lester F. Ward, writing in 1891, expressed the view that the flora of the New York-Virginia area fixes the horizon of the so-called 'Newark formation' with almost absolute certainty at the summit of the Triassic system, and narrows the discussion down chiefly to the verbal question whether it shall be called Rhaetic or Keuper. . . . . The beds that seem to be most nearly identical, so far as the plants are concerned, are those of Lunz, in Austria, and of Neue Welt, in Switzerland. These have been placed by the best European geologists in the Upper Keuper. Our American Trias can scarcely be lower than this, and it probably cannot be higher than the Rhaetic beds of Bavaria."

After a very careful comparison of the Newark fishes with those of several European faunas, Eastman holds that the fishes seem to indicate a somewhat earlier date. He says (p. 32): "This tends, therefore, to confirm the conclusion already put forward that the Triassic fish fauna of eastern North America is of a more or less manifold nature, and corresponds in a general way to the interval between the Upper Muschelkalk and the basal division of the Keuper in the Mediterranean region."

So far as the terrestrial vertebrates are concerned the evidence is at present less conclusive. *Rutiodon* spp. and *Stegomus arcuatus* from the lower series of coarse granitic sandstones below the anterior trap sheet are most nearly allied to *Mystriosuchus* and *Aëtosaurus* respectively, from the Stubensandstein (Middle Keuper) of Württemberg; while the first recorded dinosaur footprint is from the anterior shales in the Connecticut valley in America, and, if I am not mistaken, from the Triassic conglomerate of South Wales, Upper Keuper in age, in Europe (Sollas 1879). The very extensive footprint fauna from Storeton near Liverpool (Beasley 1906), which is of Lower Keuper time, contains quadrupeds exclusively, all of which are very unlike the recognized tracks of dinosaurs.

In the Connecticut valley the upper series of sandstones and shales contain the footprints in great profusion, and in fewer instances the bones of dinosaurs and other forms of the newer Newark fauna, all of which are apparently not earlier than the Upper Keuper. The coming of the dinosaurs from the Old World, the time of which may possibly be definitely fixed, is an event of such moment that it may well usher in the beginning of a new period of geologic time, and thus the Newark system as a whole may bridge the time between the Triassic and the Jurassic,

GEOLOGIC SECTION
OF THE TRIASSIC OF CONNECTICUT

Character of sediment	Thickness	Characteristic fossils
Upper series of sandstones and shales with local conglomerates	3,500 ft.+	The great majority of known footprints of all varieties, vertebrate and invertebrate; also *Mormolucoides articulatus*. *Anchisaurus* spp., *Ammosaurus*, and *Podokesaurus*, among dinosaurian skeletons. *Stegomus longipes*, skeleton.
Posterior trap sheet	100 to 150 ft.	
Posterior shales	1,200 ft.	Dinosaur tracks. First presumably plant-feeding dinosaur footprints known. Mt. Tom East, Middlefield, etc. Plants and fishes in black shales.
Main trap sheet	400 to 500 ft.	
Anterior shales	300 to 1,000 ft.	First known dinosaurian footprints. Carnivores. Mt. Tom West and Mt. Holyoke; Higby. Plants and fishes in black shales.
Anterior trap sheet	250 ft.[1]	
Lower series of coarse granitic sandstones, shales, and conglomerates, with intrusive sheets and dikes of trap	5,000 ft. to 6,500 ft.	*Rutiodon* (*Belodon*) *validus*. Simsbury. *Rutiodon manhattanensis*. Ft. Lee, N. J. *Stegomus arcuatus*. New Haven.

Gneisses, schists, and granites
Pre-Mesozoic

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[1] Near the northern boundary of Connecticut, the anterior trap sheet thins out and disappears.

in the sense that the American Morrison in the west and the Potomac in the east seem to be transitional between the Jurassic and the Lower Cretaceous[1].

THEORIES REGARDING DEPOSITION OF SEDIMENTS

In a region of the classic interest which envelops the Connecticut valley, embracing as it does some of our most venerable seats of learning, and cradling some of America's greatest geologists, it is not surprising that discussion as to the origin of the Newark deposits should have been animated. The theories of the method of deposition vary all the way from submarine through estuarine to continental, and involve a considerable range of climatic conditions as well.

THEORY OF TIDAL ESTUARY

Sir Charles Lyell, who traveled extensively in North America in the years 1841-2, was intensely interested in the fossil footprints and attendant phenomena which he observed in company with Professor Edward Hitchcock in the latter's cabinet at Amherst, but especially in the classic locality at Smiths Ferry near Northampton, where there may still be seen rock *in situ* bearing the huge imprints of *Eubrontes giganteus,* but where in Lyell's day many other tracks were extant. Lyell says: —

" The rock consists of thin-bedded sandstone alternating with red-coloured shale, some of the flags being distinctly ripple-marked. The dip of the layers, on which the Ornithichnites are imprinted in great abundance, varies from eleven to fifteen degrees. It is evident that in this place many superimposed beds must have been successively trodden upon, as different sets of footsteps are traceable through a thickness of sandstone exceeding ten feet. My companion also pointed out to me that some of the beds, exposed several yards down the river, and containing Ornithichnites, would, if prolonged, pass under those of the principal locality, and make the entire thickness throughout which the impressions prevail at intervals, perhaps, twenty or thirty feet. We cannot, therefore, explain these phenomena simply by supposing a large sheet of mud to have been spread out by the tidal waters, as may be observed on the broad flats bordering the Bay of Fundy. These last, it is true, ... exhibit the recent footprints of birds, in many successive layers, for a depth of two or three inches; but I cannot conceive of such markings to extend through a thickness of twenty-five feet without supposing a subsidence of the ground to have taken place from time to time during the deposition of the layers on which the birds walked" (1845, vol. I, p. 200).

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[1] Dr. R. Broom, the well known paleontologist of South Africa, in an address delivered before the Geological Club at Yale University in January, 1914, stated quite positively his conviction that the South African dinosaur *Massospondylus* was a very near equivalent of *Anchisaurus*, expressing the opinion that were they found in the same continent the several species would bear the same generic name. This conclusion was reached after a careful examination of the *Anchisaurus* types preserved in the Yale Museum. *Massospondylus* Broom refers to Lower Jurassic age, and he therefore stated his belief that *Anchisaurus* was also Jurassic. If this be true, it is a striking confirmation of the above conjecture, which was written several years before.

Later, in volume II, p. 139, in describing the shores of the Bay of Fundy, Lyell says: —

"The waters of the Bay of Fundy become charged with this red sediment by undermining cliffs of red sandstone and soft red marl; and in places where they overflow the alluvial plains, they throw down red mud wherever the velocity of the current is suspended at the return of the tide. Many extensive and level flats of rich land have thus been formed naturally, and many thousand acres of the same have been excluded artificially from the sea by embankments. When I arrived in this region, it was the period of the lowest or neap [spring] tides, so that large areas, where the mud had been deposited, were laid dry, and in some spots had been baking in the hot sun for ten days. The upper part of the mud had thus become hard for a depth of several inches, and in its consolidated form exactly resembled, both in colour and appearance, some of the red marls of the New Red sandstone formation of Europe. The upper surface was usually smooth, but in some places was pitted over with small cavities, which I was told were due to a shower of rain which fell eight or ten days before, when the deposit was still soft. It perfectly recalled to my mind those 'fossil showers' of which the markings are preserved in some ancient rocks, and the origin of which was first correctly explained to an incredulous public by Dr. Buckland in 1838. I have already alluded to such impressions of raindrops in speaking of the ripplemarked flags of the New Red sandstone at Newark in New Jersey."

"On the surface of the dried beds of red mud at Wolfville on the Bay of Fundy before mentioned, I observed many worm-like tracks, made by Annelides which burrow in the mud; and, what was still more interesting to me, the distinct footmarks of birds in regular sequence, faithfully representing in their general appearance the smaller class of Ornithichnites of high antiquity in the valley of the Connecticut before described."

Lyell goes on to say that he secured some of the pieces of the dried and sun-cracked red mud which he presented to the British Museum in London. Other specimens showing both the shower prints and, on another slab, the foot-marks of the sandpiper (*Tringa minuta*), he presented to Mr. W. C. Redfield, by whom they were bequeathed to the Yale University Museum where they are now exhibited with the fossils from the Connecticut valley.

These observations of Lyell were in the main responsible, if I mistake not, for the estuarine theory of the origin of the Newark deposits, a theory which held sway for half a century.

A summary of the estuarine theory was given by Kümmel (1898, pp. 147-148) as follows: —

"The Newark beds were deposited in shallow estuaries whose shores were laid bare for considerable distances by the retreating tide, and in which varying currents deposited coarse and fine materials. Shallow-water conditions prevailed during the entire period of deposition. Since the beds are many thousand feet thick, subsidence of the estuary bottom took place simultaneously with the sedimentation. The material was derived from the adjoining land areas on the northwest and southeast [in New Jersey]. The comparative absence of crystalline pebbles and the great abundance of crystalline residuary material indicate that at the beginning of Newark time the rocks were very deeply disintegrated. The thickness of this mantle is best explained by supposing that the adjoining land was at or near base-level. The presence of pebbles several inches in diameter in the Newark beds indicates that during the period of deposition the streams had a velocity not consistent with streams on a peneplain. It is believed, therefore, that an elevation of the neighboring land areas marked the beginning of the Newark time. The subsidence of the estuary bottom was probably complementary to the elevation of the adjoining areas.

" Along the northwestern shore of the estuary the waves beat upon cliffs of limestone and quartzite more than of gneiss or granite, and so formed chiefly quartzite and limestone conglomerates. But the rivers drained large areas of crystalline rocks. No evidence of glacial action was found in connection with the massive conglomerate beds, which are undoubtedly the work of the waves and ocean currents. They do not belong to any single horizon, but are shoreward correlatives of the various shales of the middle of the estuary.

" The deposition of the sedimentary beds was interrupted by at least three great lava flows, separated by long intervals of quiet, during which sedimentation continued as before. The lava flows occurred much nearer the close than the beginning of Newark time as represented by the New Jersey beds. At some period, probably after the surface lava flows, great sheets of molten rock were intruded into the shales, but did not reach the surface within the area under discussion.

" The period of sedimentation was brought to a close by the elevation of the beds above sea-level. This was accompanied by tilting and gentle folding. The faulting is believed to have occurred at the same time. The nature of this force is not well understood. The view which connects the tilting and faulting with widespread movements in the underlying rocks, by virtue of which the old surface was deformed so that the Newark sediments settled down upon it as best they could, seems best to accord with all the facts.

" Since their elevation they have been greatly eroded. The constructional surface consequent upon folding and faulting has entirely disappeared. The region has been base-leveled once, elevated, nearly base-leveled again on the belts of softer rock, and again elevated. Leaving out of account the comparatively slight modifications due chiefly to the Glacial period, the present topography is the result of erosion. Thousands of feet have been denuded from the present surface. The hills and ridges owe their height solely to the fact that their rocks have better resisted the agents of denudation than have the rocks in the valleys."

Emerson in the Holyoke Folio (1898 B, p. 3), in applying the estuarine theory more specifically to the Connecticut valley, speaks as follows: —

"The events of the Paleozoic age, constituting a prolonged history of geographic changes, had come to a close, and a land not greatly unlike the present in general configuration had been established, when a new sedimentary record was begun in a bay occupying the position of the Connecticut Valley in Connecticut and Massachusetts. The shores of the bay were the west scarp of the Worcester County plateau on the east and the east scarp of the Green Mountain plateau on the west, and extended from near Brattleboro, Vermont, to New Haven, Connecticut. The sea waters rose to a considerable height above the present level of the bordering plateaus, and spread sediments brought in from these elevated regions on either side of the bay. The shoreward sediments on the east are represented by the Mount Toby conglomerates, and the Sugarloaf arkose is the synchronous deposit formed along the western shore. The Longmeadow sandstone was deposited in the shallower and quieter off-shore area, and in the central zone of the latter area, where the basin was widest, the still finer Chicopee shale was laid down. All these deposits are partly contemporaneous sediments, differing as the strength of the current and the character of the shore rocks affected them. Strong tides, like those of the Bay of Fundy, seem to have swept up the west side of the bay, carrying the material of the granitic shore rocks far north, to rest against a shore made of the dark schists, and the return currents ran along the east shore, carrying the eastern shorewash south, while quieter waters and shifting currents spread the sediments in the central area.

"The accumulation of sediments was interrupted by an eruption of lava through a fissure in the earth's crust, which opened along the bottom of the basin. The lava flowed east and west on the bottom of the bay, as tar oozes and spreads from a crack, and solidified in a sheet which may have been 2 or 3 miles wide and about 400 feet thick in its central part. This is the main sheet, or Holyoke diabase. The sheet was soon covered with sand layers, but its thickness was such that it had shallowed the waters to near tide level, and thus occasioned extensive mud flats. This was an area suitable for the formation and preservation of unique records of the life of the time. The curiously shaped and often huge reptiles of that age wandered over the mud exposed at low tide, and their footprints, being covered by the deposit of the next flood tide, constitute the so-called 'bird-tracks' which have been found in such great numbers and perfection.

"The sands had reached a considerable thickness over the first trap bed when a second outflow of the trap followed, represented by the posterior bed, or Hampden diabase. Immediately after the outflow of this sheet an explosive eruption took place, and blocks of diabase and pulverized lava were spread by the waters over a broad area, forming the Granby tuff bed. A third period of volcanic activity followed, during which a line of small volcanoes broke out along the old fissure beneath the bay. The area was next the scene of dislocations or faults, by which the mass of sedimentary and volcanic rocks was divided into great blocks, often extending north and south. The blocks slipped one past another along nearly vertical planes. In these dislocations the strata were generally tilted eastward. . . . . In these movements, associated perhaps with general uplift of the area, the bay became land and the rocks were exposed to erosion."

THEORY OF CONTINENTAL DEPOSITION

A view of the deposition of the Newark rocks more in keeping with the organic phenomena is that set forth by Davis in 1898 (pp. 32-34) as follows:—

"The pre-Triassic peneplain might have been warped so as to alter the action of the quiescent old rivers that had before flowed across it, yet not to drown or to pond them. Such a change would set the streams to eroding in their steepened courses, and to depositing where their load increased above their ability of transportation. As with marine or lacustrine deposits, the thickness of the strata thus produced would depend on the duration of the opportunity for their deposition. A progressive warping, always raising the eroded districts and depressing the area of deposition, would in any of these cases afford the condition for accumulating strata of great total thickness. The heavy accumulations of river-borne waste on the broad plains of California, of the Po, or of the Indo-Gangetic depression, all agree in testifying that rivers may form extensive stratified deposits, and that the deposits may be fine as well as coarse. They are characteristically cross bedded and variable, and they may frequently contain rain-pitted or sun-cracked layers. . . . .

"In contrast to marine deposits, Penck has suggested the name 'continental' for deposits formed on land areas, whether in lakes, by rivers, by winds, under the creeping action of waste slopes, or under all these conditions combined. This term seems more applicable than any other to the Triassic deposits of Connecticut. It withdraws them from necessary association with a marine origin, for which there is no sufficient evidence, and at the same time it avoids what is to-day an impossible task — that of assigning a particular origin to one or another member of the formation. A continental origin of the formation would accord with Dana's conclusion that the Triassic beds 'are either fresh-water or brackish-water deposits.' There may possibly be included an occasional marine deposit along the axis of the depressed trough, for at one time or another a faster movement of depression than usual may have outstripped deposition and thus caused submergence; but, in the absence of marine fossils, the burden of proof must lie on those who directly maintain the occurrence of marine deposits.

"It requires a conscious effort to picture the geographical conditions that must have long prevailed within and around the depressed area in which the strata were accumulated. The bedding planes of the strata, revealed only in scanty exposures in which the Triassic strata are generally worn across their edges, must in imagination be transformed into broad floors of washed sands and pebbles, derived from a land area on the west or east, and gradually drifted from the margin toward the middle of the trough, where they accumulated. For every grain remaining in a sandstone bed, thousands of grains must have gone past it, slowly moved by transporting agencies, slowly worn finer and finer. Every layer seen to-day is more a witness of transportation than of deposition. The sands were not washed directly to their place of settlement and there at once deposited; they were gradually moved along the water floor. The finest silts may have been actually carried in muddy lacustrine or estuarine waters, but they must have been many times laid down and taken up before finding a final resting place. The coarse beds are to-day generally found near the margin of the formation, on the east or west; but sometimes pebbles or cobbles up to 6 or 8 inches in diameter are found near the medial axis of the lowland, as north of Meriden. Such strata may be taken to indicate a more than ordinary activity of transporting forces in the middle of the depressed area, probably during a time of less rapid depression of the region than usual, and an encroachment of the coarser marginal deposits on the flatter surface of the finer sediments along the middle of the trough. On the other hand, fine-textured and evenly laminated shales sometimes occur close to the border of the lowland, as in the curves of Pond and Totoket mountains, north of Branford; and these must be taken to indicate periods when the tranquil middle waters reached over a broader area, probably because of an increase in the depth and breadth of submergence, and possibly because of a less active supply of sediments from the adjoining lands.

"Every pebble, every grain of sand, every particle of silt, is best understood as having been made in the manner of to-day — detached by weathering from the adjoining land surface and moved downhill in the creeping soil cap, carried down valleys by the wash of streams, or drifted from deltas into shallow lakes. There may have been storms and floods then as now, but there is no sufficient reason for supposing that Triassic time was significantly more unquiet than is the present. As the hills of New England are weathering and wasting before our eyes, as the streams are flowing down their valleys, so can we best picture them on the ancient New England of Triassic time. Only in this deliberate manner must the accumulation of one stratum on another be imagined. Even the coarse bowlders of the marginal conglomerates, such as occur inside of the Pond and Totoket crescents, must have long rolled along the water courses from their source, and must have witnessed the passage of a great volume of finer materials over their heads before they were finally buried.

"Cross bedding and ripple marks are among the commonest of the detailed structures in the Triassic strata. Hence we are assured the sediments did not advance by a steady and rapid movement from margin to center, but by an intermittent migration, settling down for a time and perhaps buried to the depth of a foot or more, only to be uncovered and drifted along again in the general line of progress. Deposition, on the whole, prevailed; but at any one point the deposited material can have been only a small residue of the transported material. Ages and ages must have passed, every day of which had its deliberate dawn and close, every year of which must have shown only such minute changes as are now to be witnessed in the wearing down of uplands and in the filling of lowlands; yet in the end the Triassic strata grew to be two miles thick."

In general, geologists now regard the theory of continental origin as definitely proven.

The Physical Environment

The weight of evidence seems to show that the physical environment within which the animals of the Triassic lived, was connected with the several broad depressions along what is now the northern Atlantic coast. It is, nevertheless, inconceivable that creatures of such ample locomotive powers as the majority of the Connecticut valley remains would imply were limited to the actual troughs, but they must have roamed far and wide across the uplands as well, though naturally records of their wanderings would only be made where sedimentation was in progress.

CLIMATIC INDICATIONS

The climatic conditions of Triassic time may be judged by three criteria: the character of the sediment itself, the physical phenomena impressed upon the strata, and the evidence of the organic life.

EVIDENCE OF SEDIMENTS

No one has studied the relations between climate and terrestrial deposits to a greater extent than Barrell, from whom I may quote as follows (1908, pp. 182, 259): —

"It is concluded, therefore, that an examination of the character of the matrix or associated fine beds is of importance in determining the climatic conditions attending the origin of a terrestrial conglomerate or sandstone. This conclusion may be illustrated by contrasting the red sandstones and shales, occasionally conglomeratic, of the Connecticut Valley, with the predominantly gray conglomerates and black shales of the Carboniferous basin of Rhode Island; the two regions being separated by less than fifty miles, and both containing sediments of rather local origin. There are strong evidences in each case indicating subaerial origin, much of which however is not published. The dominant red color of the whole of the Triassic formation, considered in connection with its feldspathic sandstones indicative of the kind of erosion, mud-cracked shales, disseminated gypsum and calcite, indicative of conditions of sedimentation, point on the one hand to a subarid climate, while the carbonaceous and leached shales of the Rhode Island coal measures indicate a climate markedly pluvial and cool. . . . .

"Turning to the past, ... we may point out that the coarse, coal-measure conglomerates of the Narragansett Basin, and the less coarse, but still conspicuous, Triassic conglomerates of the Connecticut Valley, both give evidence of rather local derivation and of continental deposition. . . . . The local origin and coarse texture indicate deposition upon slopes of at least from five to ten feet per mile and possibly much greater, sufficient, under the usual climatic conditions, for good drainage. The Triassic conglomerates of the Connecticut Valley show a large amount of fragmentary fresh feldspar, iron completely oxidized, and no trace of carbon, either in the matrix or associated red shales, the fish fossils being found in the rare black shale bands. The conglomerates of the Narragansett Basin, on the other hand, with the exception of the Wamsutta beds, show a bleached matrix containing more or less carbon, and are associated with a great volume of highly carbonaceous shales.

"From these facts alone, therefore, it would be judged that the Carboniferous conglomerates, granting their subaerial origin, were accumulated during a period of cool and more or less continuously rainy climate.

"The Triassic conglomerates, on the other hand, are associated with many features of climatic significance . . . which independently indicate a semiarid climate with hot summers and possibly cold winters. The characteristics, therefore, of these conglomerates, originating from the same geologic province, but in climatically dissimilar geologic times, are such as to emphasize the importance of the present conclusions regarding climatic influences upon the deposits of piedmont slopes."

Fenner (1908, p. 305) in describing the shales of the New Jersey Newark area summarized the physical phenomena thus:

"These are well described by the term 'ferruginous silicilutytes' of Professor Grabau's classification; that is, they are finely-comminuted siliceous material, strongly impregnated with oxide of iron. Their laminations may be paper-like in thinness but are generally coarser. On exposure to the weather they break up into a multitude of crumbly fragments. Mica scales are very plentiful. The surfaces of the laminæ frequently show a multitude of irregular markings — grooves, pits, curved lines, lumps, smooth patches of irregular shape, etc., not all of which can be deciphered with any certainty. Many, however, can be identified. Mud-cracks, rain-pits, and worm-grooves are frequent. Rill-marks are sometimes found. At times films of impalpable sediment are found in the depressions in the lumpy surfaces of certain sandstone layers, which, in their delicate markings, suggest irresistibly the frothy scum left in hollows after a rain."

EVIDENCE OF PHYSICAL PHENOMENA

One very characteristic physical phenomenon impressed upon the sandstones and shales of the Connecticut valley is that of mud-cracking as the fresh deposits dried under the ardent heat of the Triassic sun. These cracks are often found associated with the fossil footprints, and in many instances, notably from the Portland, Connecticut, sandstone quarries, they lie in the axes of the digital impressions, often radiating from the tips of the toes, thus showing conclusively that the drying was subsequent to the passage of the animal, the cracks following the already weakened lines of the least resistance. In speaking of these cracks as further evidence of climate Barrell says (p. 273): —

"The alluvial soils of semiarid flood plains are particularly liable to become deeply mud-cracked during the seasons of drought, but this cracking may or may not be preserved in the sedimentary record. Over the regions of alternating sands and clays where the clay is not calcareous the conditions are most favorable for the formation and preserval of mud-cracks. The importance of mud-cracking in further drying out the soil and tearing the roots of plants has recently been pointed out by Hilgard. The climatic point where mud-cracking becomes broadly effective upon the clays of a flood plain is therefore rather a critical one tending to separate the floral characteristics of well-watered from subarid climates."

Yet another very characteristic Connecticut valley phenomenon is that to which the elder Hitchcock gave the poetic name of "Nature's Hieroglyphics" (1858, pp. 169-170; pl. LVI, figs. 1-3). As he says, the most remarkable locality is at the Portland quarries, "where sometimes the surface looks like mosaic, or rather like a pavement of polygonal masses, with mortar between the pieces." Barrell describes this as "mud-cracks filled with æolian sands." He says (p. 279): —

"Silt and sand will be blown over and fill up the cracks developed by the drying of argillaceous water-laid deposits. Consequently, the sand is filled in under the raised rims of the polygonal discs and becomes continuous with the mantle of sand above. In this way, the concavity upward of the individual plates is preserved, and the mud-cracks are not obliterated, even in a silty clay which would slack and crumble immediately upon being re-wet by the advancing waters of the following inundation. Experiments by the writer [Barrell] go to show that the upturned edges of the clay plates would not usually hold their form while the broad sweep of sand-laden waters should deposit clean sand both under the edges and over the plates. The concavity of the plates thus testifies to æolian burial, and such may be distinguished from mud-cracked flats buried by fluvial action."

This same phenomenon has been witnessed by Rogers in Griqualand West, South Africa, by Bowman in Iquique, Chile, and by Huntington in the great basin of Lop, in western China; so it is seen that this method of the preservation of mud-cracks is not only widely prevalent upon the flood plains of arid regions at the present time but has been also observed as widely developed in certain ancient formations.

Other phenomena indicative of climatic conditions are the presence of impressions of frequent hard showers such as are often observed in semi-arid regions. Except for their apparently recent origin, pieces of sun-cracked mud deeply pitted with raindrop impressions secured by Professor Marsh on the Laramie plains in 1868 might well be of Triassic origin. The surface of the Laramie mud bears the bright, almost porcelain-like lustre seen in pebbles and other fragments which have been subjected to the scouring effect of desert winds.

Other phenomena, namely, the impressions found in Portland and attributed to a fucoid to which was given the name of *Dendrophycus triassicus* by Newberry (1888, p. 82), have been seen in actual formation upon the clay banks of the streams, and are nothing more or less than wonderfully wrought-out series of branching rill marks made by tiny streams of trickling water.

EVIDENCE OF ORGANIC LIFE

The animals of the Connecticut Trias, which will be discussed more fully in a later chapter, in so far as they throw light upon past climatic conditions, include the remains of at least two species of shells, both belonging to the fresh-water Unionidæ, which precludes the possibility of saline waters, at least in the neighborhood of Wilbraham, Massachusetts, a locality which, unfortunately for the estuarine theory of origin, is far to the south of places in which the sedimentation would seem to demand the strongest tides. On the other hand, the presence of the shells implies more or less permanent waters, either in slow moving or impounded condition. The one insect reported from the valley is found in great abundance at Turners Falls, Massachusetts, and has been described as the aquatic larva of a neuropterous insect, hence again implying the presence of waters of some duration. If the period of larval life was equivalent to that of the ephemerids of to-day, the water must have continued not one season alone but three. This may, however, have been an annual insect the larval life of which would require but a transitory stream.

The invertebrate trails show no characters which would debar them from such a climatic environment as Barrell has assumed for the Connecticut Trias. Fishes are without exception ganoids; and, while confined stratigraphically to two or three black shale bands, their geographical range is from Turners Falls to New Haven. They may be, however, all of fresh-water affinities,[1] and may well represent the recurrence of periodical climatic cycles of greater than the average humidity and consequent expansion of the aquatic habitat, or a disturbance of the drainage, climatic conditions remaining constant. The origin of these black shale bands will be discussed in detail below (see p. 38).

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[1] Eastman 1911, p. 21, says: "While there is nothing in the character of the fossil fishes which would prove conclusively whether the deposits were formed in salt or brackish or fresh water, the physical character of the deposits and the fossils other than fishes found in them make it substantially certain that the deposits are not marine."

Over the terrestrial vertebrates, aside from a few of the forms unquestionably dinosaurian, so deep a shadow of obscurity rests that safe conclusions may hardly be drawn. There is no reason to suppose that all are reptilian; and, if the Amphibia of that day were of similar constitution to their *present-day* descendants, to whom a one per cent. solution of salt is fatal, the proof of their presence would preclude the possibility of marine waters, and add their evidence in favor of continental deposition to that of the lower forms. There are, however, stegocephalians known from brackish-water deposits.

On the Laramie plains in 1899, when conditions were dry even for a semi-arid climate, I found in the dust of the ground within the tent a large and lively salamander of brilliant coloring whose advent and departure were alike mysterious. Van Dyke in his description of the desert remarks that all desert trails run in straight lines, showing the animal to be not prowling but intent upon getting across to the mountain. The same is true of the fossil trails of the Connecticut valley; and, from the compact type of foot, long stride, sometimes suddenly lengthening marvelously, and the narrow trackway of many species, it can be easily seen that the character of speed and great traveling powers imposed by the desert was here at a high premium. As I have shown elsewhere (1910, p. 5), a climate of semi-aridity, compelling cursorial adaptation as a means of getting food but more especially water, may well have been an impelling cause in dinosaurian evolution. Bipedality among lizards of to-day is, so far as I am aware, confined to denizens of semi-desert environment, certain instances being the large frilled lizard, *Chlamydosaurus,* of Australia, and several lacertilian species of our own Southwest.

That water was rare and at a premium when the rains did come is evidenced by the frequency of the association of rain-prints with the dinosaurian tracks and the above mentioned mud-cracks which *followed* the passage of the animal. Again the depth of the impression of the tracks of two species of animals upon the same strata is sometimes entirely out of proportion to

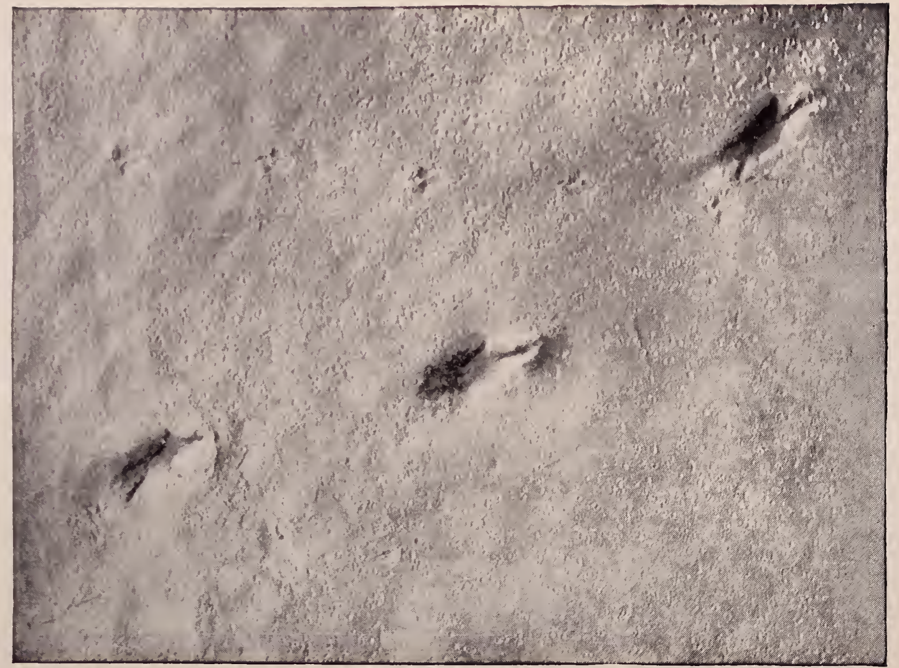

PLATE I.—Slab showing passage of two dinosaurs after a shower. The lesser is *Argoides minimus*, and the greater, *Steropoides diversus*. Locality, near Turners Falls, Mass.

the apparent difference in the makers' size, for the presumption is that then as now the supporting area of an animal's feet must have borne a certain ratio to the weight in accordance with the type of environment to which it is adapted. The inference is therefore that the passage of the two animals was on their way to or from a water hole during a period of desiccation, and that the deeper impression was made some time before the shallow one and nearer the time of the preceding rains. (See Plate I.)

The evidence of the footprints has been cited by Davis (1898, p. 30) as a final proof of the deformation of the valley subsequent to the deposition of the beds, which now stand with a dip of 10 to 15 degrees, which some have contended was actually the angle of the slope of deposition. Davis says: —

" Furthermore, as Hitchcock long ago pointed out, the numerous reptilian footprints, large and small, of which so large a collection is preserved in the museum at Amherst College, testify unanimously that the soft sands and muds over which the Triassic reptiles walked lay essentially horizontal when the prints were made, for the prints are square with the bedding, and not oblique, as they must have been had the reptiles walked along a sloping surface. It might be added that the tracks, when seen in the sandstone quarries, lead in all directions, and not prevailingly along the strike of the strata, as might be expected if the present dip of the beds indicated their original attitude."

VEGETAL LIFE

With regard to the probable vegetal life of the Connecticut valley during the time under discussion, I may again quote from Barrell, and later from Chamberlin and Salisbury.

Barrell (1908, p. 274) under the title " Floral Characteristics of Semiarid Flood Plains " speaks as follows: —

" One of the most secure means at present commonly used to determine the climate of a past age consists in the study of a fossil fauna and flora, the identification of genera and species, and the inference that the optimum climatic environment for such organisms has remained the same from the past to the present time. As examples may be cited the conclusions in regard to the warm polar climate of the Miocene based on the presence of magnolias in Greenland, and the same in Mississippian times as determined by fossil corals in the rocks of Spitzbergen. . . . . .

"The vegetation of the flood plains of semiarid climates is more largely arboreal than that of the inter-stream slopes. Many large tracts of the flood plain away from the river banks are, however, either sparsely covered with trees or given over to grass land. Even the latter may find difficulty in existing where an unfavorable nature of alluvial deposit is added to the unfavorable conditions of a hot or dry growing season. The occupancy of the soil by grass or forest depends upon the underground water. For forests there must be an adequate amount of moisture in the subsoil during the growing season, though this water may have come from winter floods or rains. For grassy plains the water in the subsoil is immaterial, the essential condition being a moist soil during the season of growth. Although the level of the ground water in flood plains of even subarid climates may lie not many feet below the surface, the alternate stratification of fine sand and clay which is frequently present is very unfavorable for a forest vegetation. The clay is capable of carrying the water upward to a greater height, even as high as ten feet, but transmits it very slowly. The sand, on the other hand, cannot lift the capillary water more than one or two feet, but does this very quickly. If the upper portion of a sand stratum is dry, the plants cannot feel the moisture below and will fail to send roots after it. In the presence of such strata a vegetative covering of bunch grass is to be expected, leaving no appreciable organic record. A deep loamy soil favorable for storing water and for its capillary rise is the most favorable condition for the growth of trees and shrubs over semiarid flood plains. The roots in such cases strike downward rather than horizontally, and may penetrate to great depths, twenty feet being not uncommon. The angle of penetration of fossil roots is therefore a matter of importance from a climatic point of view. The strong oxidation acting at the surface normally destroys all vegetable tissues before they become buried in the course of time below the deep zone of oxidation, but there is a chance of finding casts of downward-branching rootlets in massive arenaceous shales and more rarely of vegetable remains buried by superficial accumulations. It is seen, therefore, that in the river deposits of semiarid climates casts of logs are most likely to be preserved in the sands deposited in the neighborhood of stream channels. At a distance from the channels, wetting and oxidation would tend to destroy the logs and larger fragments if such existed, before sufficient time had elapsed for burial. Root impressions of trees in such regions would be of more common occurrence than trunks, and confined possibly to what were originally deep loamy sands."

Apropos of this it should be remarked that the entire plant record at Portland, Connecticut, consisting as it does of the casts of trunks of trees, some of which reached a diameter of at least 35 cm., and of the anomalous *Dendrophycus,* which as I have said is now considered to be casts of rill marks in the clay of a river bank, points to the conclusion that then as now the site of Portland was in the neighborhood of a large stream channel.

Barrell further says (p. 275): —

"The herbaceous types of vegetation, however, are the more common over the well-drained portions of truly semiarid flood plains, and the plant impressions recorded in the strata would consequently be of small size compared to those of the large and luxuriant vegetable forms of more rainy climates.

"The above discussion is based on the present floral societies, composed almost wholly of flowering plants. The conclusions, however, in regard to the climatic relations of herbaceous and arboreal vegetation may with probability be extended backward in time to ages as early as the Devonian, when all plants were either cryptogamic or gymnospermous, since in the later Paleozoic, long before the advent of the Mesozoic phanerogams, plant societies existed then as now which included forms from arboreal to herbaceous and ranged in adaptation from hygrophilous to xerophilous. The present usual restriction of cryptogamic vegetation to small forms occupying habitats moist, shady, or cold, habitats not strongly sought by the higher vegetation, did not then necessarily hold; conditions to some extent perpetuated in Australia, where tree ferns still abound in the coastal districts of New South Wales and Victoria, and vascular cryptogams with xerophytic adaptations are known to occur in other portions of the island continent."

Chamberlin and Salisbury (vol. III, pp. 38-40) speak thus of the plant life of the Triassic: —

"The record of the vegetation is very imperfect. The vegetation was probably scant in reality, for . . . . arid tracts imply conditions inhospitable to plant life. An environment that could give rise so generally to coarse red sandstones and conglomerates — even limestone conglomerates — could not well be congenial to luxuriant vegetation.

"The Triassic was distinctly an age of gymnosperms the world over; the supremacy of the pteridophytes had ceased, though ferns, true to their persistent nature, still held an important place, and the equisetales were a more vital factor than now. . . . . Conifers of the types that had come in during the Permian, and kindred new ones, were prominent, while the cycadean group was still in a stage of deployment and occupied the central place of interest. . . . . The Triassic conifers bore the scrawny aspect of the walchias and voltzias of the Permian. . . . . It does not appear from the record that any of these gymnosperms were especially large, but on the contrary rather dwarfish, the conifers bearing the aspects now found on sandy barrens and arid tracts. The calamites had given place to true equiseta, which were represented by forms that were gigantic in comparison with modern types. . . . .

"In the closing stages of the period, the Rhætic epoch and its equivalents, there seems to have been much amelioration of the previous hostile conditions and a much ampler development of the flora. The larger part of the known American fossils belong to this stage. In favored portions of the Newark series from Connecticut to North Carolina, plant remains occur, and in the coal-beds of the latter state and of Virginia, the flora is more amply represented."

THE PLANT-BEARING SHALES

It will be noticed that almost all of the known plants in the Connecticut valley area come from the fish-bearing black shales, which apparently represent lakes or swamps due to the damming up of the drainage in certain areas. In such areas of arrested drainage, the vegetation would naturally be more abundant than over the rest of the valley; though it may be that the relative abundance of vegetable fossils in these localities is due chiefly to the greater chance of preservation of organic material where oxidation is prevented by immersion in water.

Exactly what changes dammed up the drainage here and there, producing lakes and swamps, our knowledge is insufficient

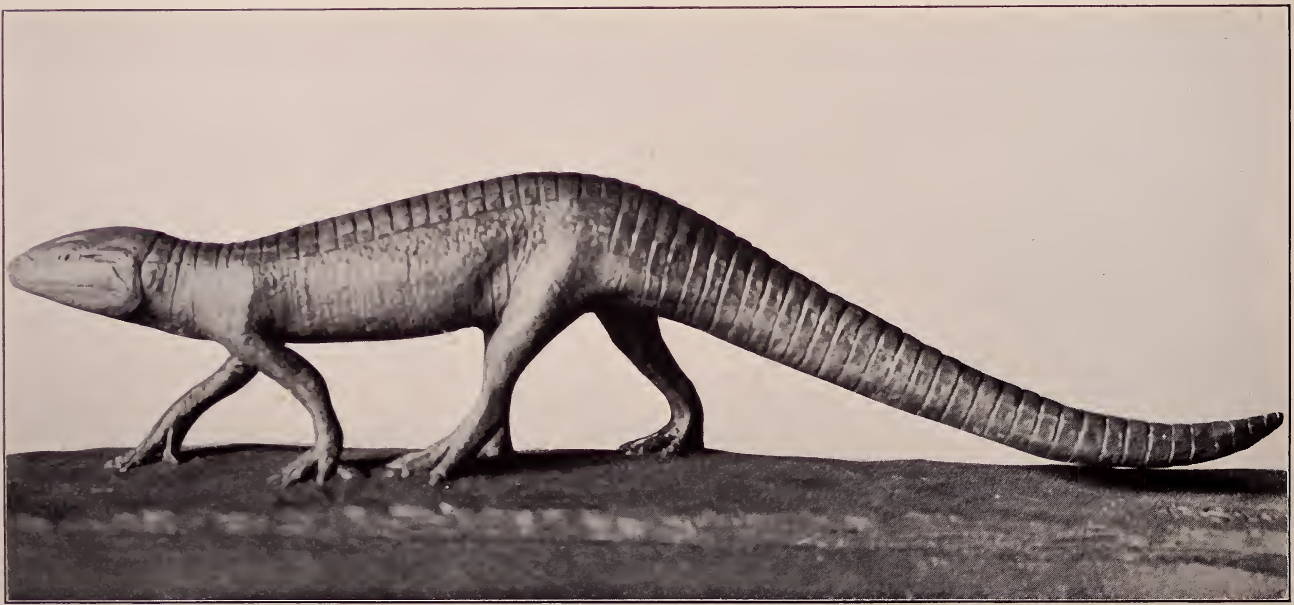

Plate II.—Restoration of *Stegomus longipes*. One-half natural size. Original.

to determine. Two suggestions are, however, worthy of consideration.

A number of the localities where the black shales have been observed are near the eastern border of the Triassic area. It is altogether possible in these cases that the damming back of the waters may be due to the growth of alluvial fans formed by detritus coming down from the Eastern Highlands. Where such fans are so frequent as to come in contact with one another, pockets are often formed in which the imperfect drainage gives rise to local lakes and swampy areas, as in the Rhone Valley or Lake Tulare in southern California.

It is also noteworthy that all but one of the well-known localities of the black shales belong to two horizons which fall within the limits of that great epoch of vulcanism to which belong the three great contemporaneous sheets of trap and probably also the intrusions of trap. The black shale at Middlefield, Conn., belongs to a horizon later, but not much later, than the time of the outflow of the posterior trap sheet. It is altogether supposable that the events connected with such an epoch of vulcanism may have produced changes of the surface which would result in extensive disturbances of drainage.

Résumé

The story of the Connecticut valley, as the evidence at hand now reveals it, may be summarized as follows:

Far back in the remote Triassic period, when the Age of Reptiles was yet young, there were laid down in a gradually deepening trough in the older rocks the great accumulations of gravels, sands, and clays, interbedded with vast lava sheets, which constitute the sediments of the Newark system. The older notions of the submarine or estuarine origin of these rocks have been abandoned on the ground of their containing no relics whatever of marine or even brackish-water origin, and of the difficulty of accounting for the deposition of the sediments except by tidal currents of far greater transporting power and governed by laws of movement at variance with any on earth to-day. On the other hand, evidence seems to point to continental deposits, the result of the ordinary subaërial agencies of winds and rains and rivers, such as require no ingenious straining of nature's laws to account for the accumulation of vast deposits in the course of time. The origin of the sediments was the wasting of the older rocks which formed the limiting highlands on either side of the depression: and the organic remains, all of fresh-water or terrestrial origin, testify to the presence from time to time at least of standing bodies of water of considerable extent; of seasonally, if not continually, flowing rivers; and of extensive land areas with slowly drying pools left after the infrequent but torrential showers characteristic of arid to semi-arid regions of the present day. That there were climatic cycles, such as Huntington has observed in the Near East, I have no doubt, and I have reason to believe from the evidence of the fossil vertebrates that the climate during the earlier part of the Newark period may have been less arid than toward its close.

The vegetation bore the mark of antiquity in its monotonous sombre greens, for brilliantly colored flowering plants had not yet appeared, and apparently there was that sparseness and lack of profusion, except locally, which characterizes our great Southwest. The plants were of three main sorts: ferns, cycads, and conifers, looked upon by existing animal life as undesirable food, but which for utter want of a better must have tempted some of the denizens of Triassic time, for we have evidence of mild-mannered herbivores among the rapacious devourers of flesh.

Of the organic remains, those of vegetable origin consist of the impressions and casts of the trunks of trees, some of the latter found at Portland being of such size as to indicate a stream of no mean transporting power; and of the impressions of leaves, twigs, and fruits, occasionally containing a delicate film of carbon which preserves the most intricate detail with wonderful fidelity. Here and there the vegetal remains were of sufficient abundance to lead to the production of black bituminous shale bands, formed during periods of the accumulation of waters which supported a teeming population of fishes; but never within this area were conditions ripe for the formation of beds of coal such as are found in the Newark beds from Virginia southward.

Animal life left its record rarely in the form of shells or bones, but in marvelous abundance in trails and footprints, some of such clarity of meaning that he who runs may read, others of

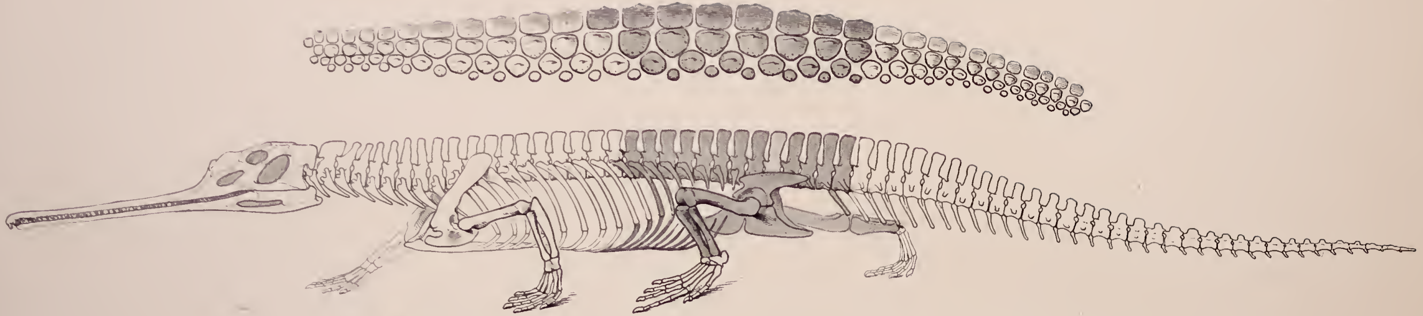

Plate III.—*Rutiodon manhattanensis* v. Huene. Showing parts preserved in the Fort Lee specimen. From v. Huene, after Matthew.

more difficult and questionable interpretation, yet others exasperating in their baffling obscurity.

Both vertebrates and invertebrates are thus represented. Of the latter the actual fossils are impressions of at least two species of shells, allied to the modern wide-spread fresh-water Unios, and a single aquatic insect species, occurring in profusion of numbers, which bears the unique distinction of being the oldest true insect *larva* known. Some of the trails are worm-like as though made by annelids, others show serially repeated footmarks in pairs, or fours or sixes or more, indicating the presence of other arthropods than *Mormolucoides,* many of which were doubtless insects, others myriapods, perhaps spiders and scorpions, and fresh-water crustaceans as well. Some of these are small and of wondrous delicacy; others, larger than the trails of any insects or fresh-water crustaceans known, must represent giants among their race.

The fishes, all of the old-fashioned armored "ganoid" sort, have been alluded to as occurring in abundance from time to time in the black shale bands, representing lake deposits with a luxuriant growth of plants.

The terrestrial vertebrate skeletons are all reptilian remains; three, those of phytosaurs, remotely related to living crocodiles, and, in one instance at least, œcologically equivalent to the fish-eating gavials of the Far East. The others are all dinosaurs of average size and representative kinds, neither the largest nor the most specialized which lived during the time of which we speak being known to us. Unfortunately, too, the dinosaurian skeletons were those of essential contemporaries, and therefore in themselves throw no direct light upon evolutionary history. Of the five species, four are so nearly related as to be of one family and three of one genus, while the other represents a different race which in its ultimate culmination was far apart from the group for which the others stand, though all were sanguinary devourers of flesh.

The footprints doubtless represent two, possibly three, great classes of terrestrial beings: Amphibia of salamandrine form were perhaps present, and doubtless representatives of the more archaic armored stegocephalians as well, though one cannot indicate the tracks of either with assurance. Of the reptiles, the possibilities of time and place would indicate lizards, turtles, and dinosaurs among the more familiar forms, and these unquestionably were represented in the fauna; and among those less known the Rhynchocephalia, phytosaurs, aëtosaurs, and theromorphs are within the possibilities. Whether or not birds were present is a mooted question. The elder Hitchcock considered all of the bird-like tracks unquestionably to have been of avian origin, but the discovery of dinosaurian remains soon swung popular if not scientific opinion to the opposite extreme, and all the tracks were believed to have been made by dinosaurs. I believe, in most instances, this group of footprints is demonstrably dinosaurian. There are some, however, of which I am not so sure; but the only final proof of the existence of Triassic birds will be the actual discovery of their remains, for the earliest yet known, *Archæopteryx,* of the Upper Jurassic, lived many thousands of years subsequent to the close of Newark time. If Professor Osborn is right in supposing the pro-avian to have been arboreal, I should not look for its trail over the sands of the Connecticut valley, and I seriously question whether at so remote a time degenerate terrestrial birds had been evolved. On the other hand the cursorial origin of birds is conceivable, and if true would be possible within the environment we are discussing.

Of the mammals, though known apparently in *Dromatherium* and *Microconodon* from contemporaneous rocks of not very remote geographical locality, we have no record. Their known habitat during the Triassic had a very different climate and vegetal environment from that of the Connecticut valley; and this, as in the case of the birds, would seem to debar them from the limits of this area.

Geologically, the history of Newark times is a tremendous drama, of which the prologue speaks of the degradation of the ancient hills, and the setting of the stage in the form of an extensive though relatively slight depression with the establishment of the sediment-bearing drainage from the environing upland. Four great acts, of which the first and last are much the longest, succeed each other in time, separated by entr'actes of appalling grandeur, when vast sheets of molten rock well from the depths, spreading far and wide, blotting out the old and preparing the stage for new and different players. Of the sequence of the scenes

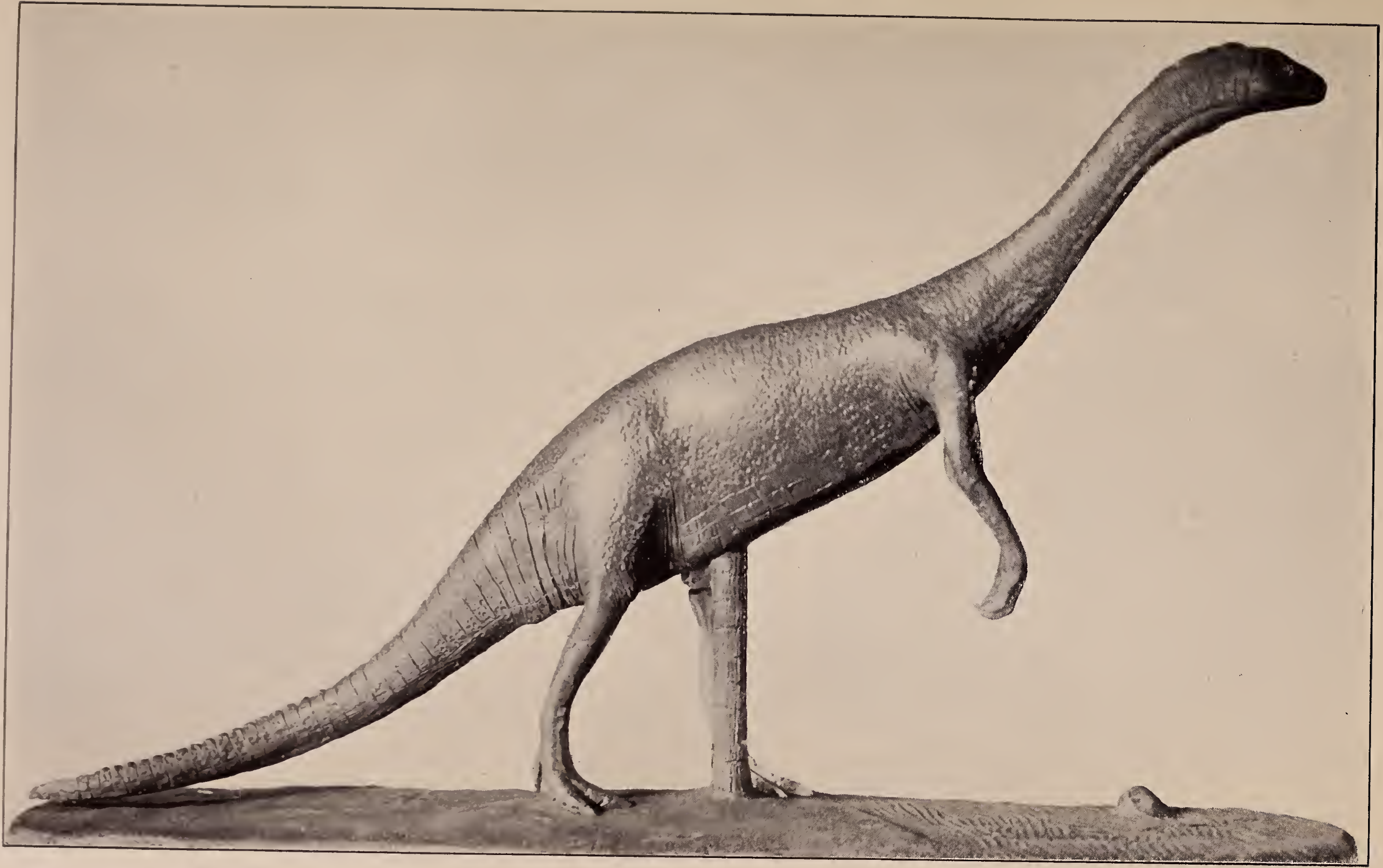

PLATE IV.—Restoration of *Anchisaurus colurus*. Flesh. One-twelfth natural size. Original.

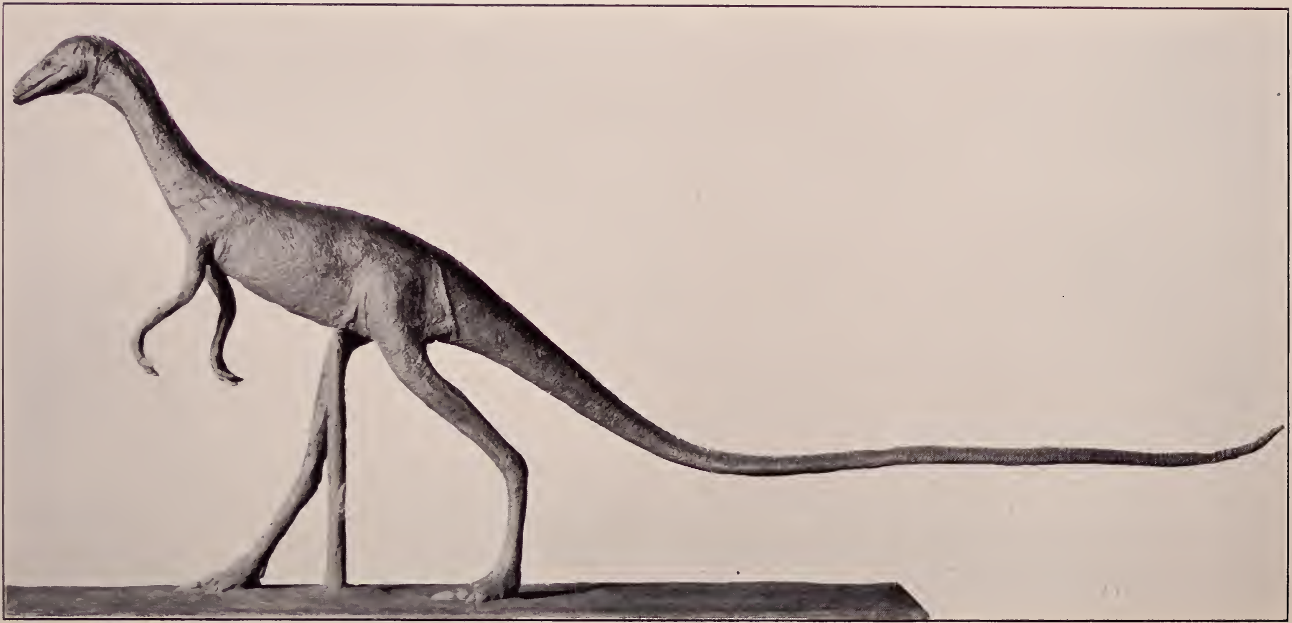

Plate V.—Restoration of *Podokesaurus holyokensis*. One-sixth natural size. Original.

within the acts the order is not so surely recorded, since they differ in their position in the valley, in the nature of the sediment in which their record is written, and in the forms that people the stage. The whole drama is incredibly long as we measure time, for each succeeding day, with its dawning, its morning hours, high noon, declining sun, and long night, adds but the smallest increment to the gradually accumulating sediments, though, as one has said, "neither time nor space flows evenly," and there are tempestuous days whose contribution to the mass makes up for the calm passage of those to follow. Yet, when one thinks of the two and one half miles of accumulations which these days represent, he can feebly grasp at a realization of the extent of Newark time.

During the long first act in the course of which are laid down the five or six thousand feet of the lower series of coarse granitic sandstones, we have but little record of the action. But two entrances are recorded, one of which is at New Haven where appears the heavily armored *Stegomus arcuatus,* whose habits we can scarcely conjecture, as the burial of its body in river sediment means little. The second scene at Simsbury is more intelligible because, while part of a shoulder blade only is preserved, it is from a representative of a genus, *Rutiodon,* which is almost completely known; hence we are justified in applying the old Cuvierian principle and reconstructing not only a long-snouted fish-eating animal from a single bone, but the stage setting of its fish-supporting aquatic environment as well.

This act closes with the first lava outpouring, the so called anterior trap, which is followed by the second act, that of the anterior shales, interesting in that it includes the first fish- and plant-bearing black shale deposits, followed in the region round about Mount Holyoke and Mount Tom by the first recorded appearance of dinosaurs in the valley. Of these, *Eubrontes giganteus,* one of the very largest, is among the first, possibly representing a form like the larger genera well known from their bones in the Old World. Others are the larger species of *Anchisauripus,* indicating the presence of *Ammosaurus*-like forms as well. This second act with but a thousand feet or less to its credit is the briefest of all, and the entr'acte following, as befits the middle of the drama, is the most stupendous, with its accumulation of 500 feet of lava, constituting the main trap sheet.

Act III, during which the posterior shales were laid down, is still more prolific of animate records, for the known footprints not only increase in number, but here for the first time we find those of *Anomœpus* giving the earliest reasonably sure record of the advent of plant-feeding dinosaurs, while that of *Grallator cursorius* shows that accompanying their larger, fiercer brethren are the lighter, more agile dinosaurs of compsognathoid type. This act includes another scene during which plant- and fish-bearing black shales are accumulated. The relative duration of these posterior shales is somewhat greater than that of the anterior, but is followed by the smallest of all the lava outpourings, that of the posterior trap.

It is only in the final act that the profusion of the cast becomes evident, for at various levels within the 3,500 feet of its accumulations, and more notably toward its close, at Portland, around South Hadley, and within and about Turners Falls, are recorded by far the great majority of the known genera and species of the footprints of the Trias, while equivalent beds, mainly from South Hadley southward to Manchester, have yielded all of the osseous dinosaurian remains. The observer is impressed with the profusion of trails which imply swift motion, as though conditions were hard and life the antithesis of one of languorous ease — the principal feature which gives rise to the belief of locally increasing aridity of climate.

Here more than in any other act of paleontological history one is conscious of an obscuring drop scene in the middle distance, behind which may be seen with tantalizing clarity the passing and repassing feet of a great host of players, some rapidly as though impelled by urgent impulse, others slow-moving, ponderous, the like of which the paleontologist has never seen. Occasionally one passes before the curtain, and there while fully exposed to our scientific vision is enacted a tragedy, for bones are ever symbolical of death; but the footprints are those of creatures in the full tide of life.

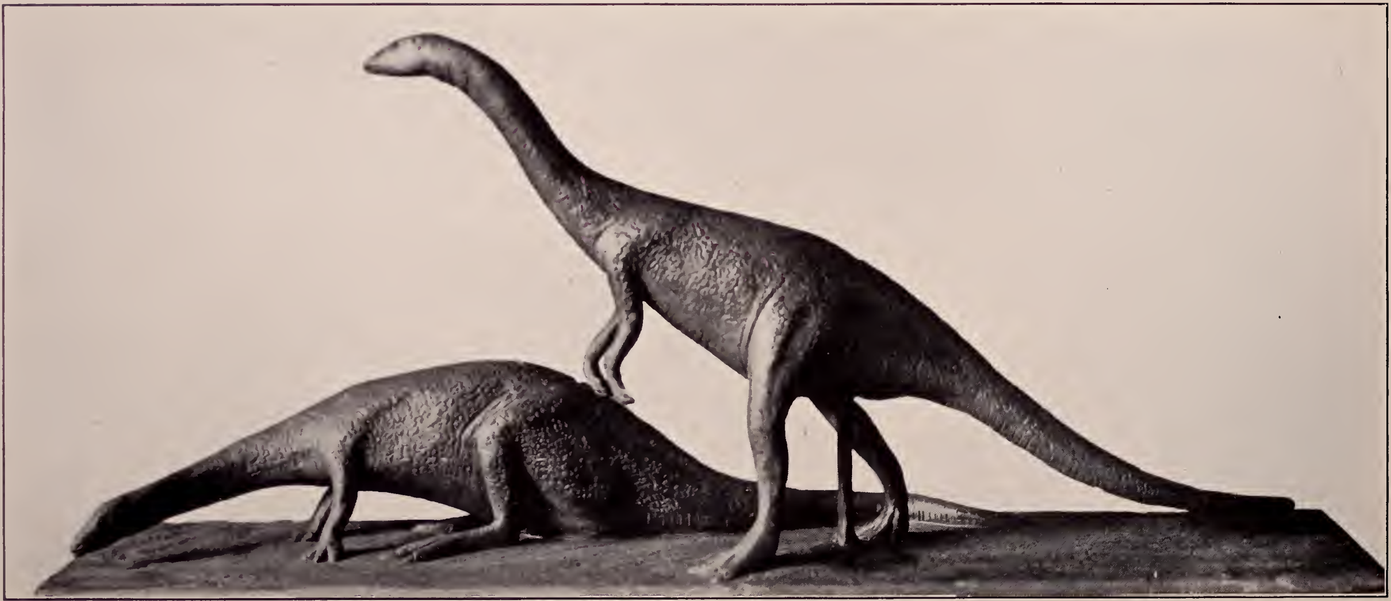

PLATE VI. — Restoration of *Anomœpus scambus*. One-fourth natural size. Original.

PART II. THE TRIASSIC LIFE

The Flora

An excellent summary of the Triassic plant life is given by Ward (1900, p. 222), from which I extract the following: The earliest mention of fossil plants in the Connecticut valley is "that by Dr. Edward Hitchcock, in the American Journal of Science for 1823, in an extended article read before the American Geological Society on September 11, 1822. Neither of the two objects found is specifically determinable, the first being some sort of cane or grass, the other a coniferous branch, possibly *Palissya* or *Voltzia*. The first was found one-half mile south of Newgate Prison, the second at Sunderland, in Massachusetts.

"The first mention made of the petrified tree found in the Southbury area of the Connecticut Trias . . . . was a paragraph devoted to it by Dr. Hitchcock in his Miscellaneous Notices of Mineral Localities, with Geological Remarks, in 1828, describing a fragment from it obtained by Dr. Smith of Southbury, broken off by a man who had mistaken it for a recent stump and ruined his axe upon it." Later investigations of Professor Bailey of West Point prove this tree to have been coniferous.

The plant localities enumerated down to the time of the publication of Newberry's Monograph on the "Fossil Fishes and Fossil Plants of the Triassic" (1888), in the chronological order of their publication, are as follows: Newgate Prison, Conn., and Sunderland, Mass.; Southbury, Conn.; "Hadley, Conn.," supposed to be South Hadley, Mass.; Deerfield and Greenfield, Mass.; Middletown, Conn.; Enfield Falls, Mass.; Suffield, Southington, and Durham, Conn.; Mount Holyoke, Mass.; Bristol, Conn,; Middlefield, Conn.; Mt. Tom, Mass.; and the quarry of Roswell Field at Gill, and Turners Falls, the last two probably identical.

Ward says further (p. 226): —

"The above enumeration brings the record of paleobotanical discovery in the Trias of the Connecticut Valley and New England areas down to the date [1888] of Dr. Newberry's Monograph of the Fossil Fishes and Fossil Plants, to which reference has already been made. In this he gives a sketch of the Triassic, and includes 17 species of fossil plants. They were collected at Sunderland, Massachusetts, at Durham and Middletown, Connecticut, and at Newark and Milford, New Jersey. . . . .

"Of recent collectors in this section by far the most successful has been Mr. S. Ward Loper, of Middletown. Mr. Loper was in the field at the time of our visit, and we met him at Tariffville, Connecticut, at which place he had discovered a plant-bearing locality. There being no true coal mines in the Connecticut Valley Trias, the mode of occurrence of the fossil plants is, of course, somewhat different from that in Virginia. It is equally true here, as in Virginia, that fossil plants are not found in the red sandstone, but are confined to the dark shales, and those in the Connecticut Valley occur for the most part in close connection with the trap ridges of that region. They are usually found at the margin of the shales near their contact with the trap. The locality at Tariffville was in close contact with one of the secondary trap ridges located on the eastern side of the main ridge, which, in the general trend of these ridges, places it higher in the Trias, geologically speaking, or, as Professor Davis expresses it, 'posterior.' From what Mr. Loper told us, and from numerous observations upon localities from which fossil plants have been previously reported, it would seem that they usually occur in this position. . . . .

"Besides examining the Portland quarries and those of Turners Falls and Gill, Massachusetts, where no vegetable remains other than those presently to be named occur, we visited several places in Connecticut where Mr. Loper had obtained fossil plants, especially at Westfield and Highlands [*sic*]. In the Portland quarries there occur large logs clearly representing Triassic trees embedded in the red sandstone and now thoroughly silicified[1]; but besides these and the fine specimens of *Dendrophycus* [*vide supra,* p. 37] which occur there, nothing of a vegetable nature seems to have been found. At Turners Falls careful investigation was made in the red shales bearing the tracks so celebrated in that locality, and under the guidance of Mr. T. M.

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[1] These logs are certainly not in any proper sense "silicified." If they are of vegetable origin, as is probable, they are not petrifications but casts.

Stoughton we visited all the important places from which specimens of interest had been taken. We saw in these beds nothing that could be called vegetable, and it seems very doubtful whether any plants either grew or were ever transported by any agency into the riparian clays in which the Brontotheria [Brontozoa] and other saurians left their footprints in such profusion."

In this connection mention should be made of a small slab of gray shale, preserved in the Peabody Museum at Yale, from the footprint locality at the Horse Race, Montague, Massachusetts, one surface of which is covered by a mass of fragments of vegetation consisting in the main of twigs and stems of conifers. They are very distinctly seen because of the film of carbonaceous material which still adheres to most of the impressions; but I believe that, if the carbon had not been preserved, or if a monotone cast were taken of the surface, the plant remains would hardly be recognized as such at all. This would account for much of the *apparent* dearth of plant remains except in the black bituminous shale bands in which oxidation has been carried to a relatively slight extent as compared with the red shale and sandstone strata.

In a joint paper by Professor Davis and Mr. Loper read at the Washington meeting of the Geological Society of America in December, 1890 (Davis and Loper, 1891) are enumerated the fossil plants and fossil fishes, found by the junior author, with their stratigraphical position, "showing those that are confined to the anterior and to the posterior shales, and those that are common to both. This enumeration includes 13 plant forms, 11 of which are specifically named. Six of these forms are confined to the anterior and 2 to the posterior shales, while the remaining 5 are common to both situations" (Ward).

The plant lists made up by Davis and Loper from the black shale areas give the following from the anterior shales: — of the Coniferæ, a gingko, *Baiera münsteriana, Pachyphyllum simile,* and *P. brevifolium;* of the cycads, *Cycadinocarpus chapini, Otozamites brevifolius,* and *O. latior;* of Equisetaceæ, a small undetermined *Equisetum* (?), and "calamite-like stems, with head"; and a plant, *Loperia carolinensis,* of uncertain botanical relationships, "probably monocotyledonous, perhaps aquatic" (Newberry). There is also found a fern, *Clathropteris platyphylla.*

The posterior shales have produced *Otozamites latior, O. brevifolius* (the latter doubtful), *Cycadinocarpus chapini, Loperia carolinensis,* and a small undetermined *Equisetum* (?), in common with the anterior; and in addition contain the cycadacean, *Ctenophyllum braunianum,* and the rush, *Equisetum rogersi.*

In addition to these plants of the black shale, certain footprint localities have produced ferns, as *Tæniopteris* in the gray sandstones of Mount Holyoke, and a very doubtful one described as *Clathropteris* at Mount Tom and at Gill, though Fontaine concludes that neither of these is *Clathropteris,* but probably *Dictyophyllum* or *Camptopteris.*

Field's Orchard quarry at Gill has also produced a cone which may be the conifer *Palissya,* and twigs of *Cheirolepis muensteri.* There is also a Palissya-like conifer impressed upon the gray shale from the Horse Race quarry at Montague. With the possible exception of the Mount Tom and Mount Holyoke specimens, these are all from localities in the upper series of sandstones and shales, and are therefore much younger than either the anterior or posterior shales.

The Fauna

THE INVERTEBRATES

ACTUAL FOSSILS

In both vertebrate and invertebrate relics the proportion of known fossils to trails and footprints is much the same, the former being of such extreme rarity as to warrant special mention of practically every find.

Of the actual invertebrate fossils the species represented are but three — two known species of molluscs, and a single insect species of which fortunately there are numerous examples, all however from two or three localities in the neighborhood of Turners Falls, Massachusetts, except a few specimens found in a railway embankment near Middletown, Connecticut.

Phylum **ARTHROPODA**
Class **HEXAPODA**
Order **NEUROPTERA**
Family SIALIDÆ

Mormolucoides articulatus Hitchcock

This creature was first described by E. Hitchcock in 1858 (pp. 7-8, fig. 1, pl. 7, figs. 3-4), though Hitchcock considered it to be a crustacean, and its true relationships were discovered by J. D. Dana to whom Hitchcock sent specimens. Dana in a letter published in the Ichnology (p. 7) and bearing the date of May 11, 1858, writes as follows: —

"I have taken up your specimen over and over again, trying to resolve doubts, but still remain undecided; my mind has gradually come to the suspicion, if not belief, that it is a larve of an insect, and not crustacean. I question much whether the depressions on the right side are impressions of true legs; and those on the other side are still less like anything of the kind; they appear to mark a line or suture in the shell of the segment. I agree with you that your artist has not done justice to the specimen. I have made a rude sketch, merely to indicate some of the characteristics which he has failed to bring out, and which appear to be of special importance. I should regard A to C as corresponding to the head and corselet of the larve (A the head, B to C the three segments of the corselet), and C to D as the abdomen. As I cannot make it crustacean, and my knowledge of insects is quite limited, I return the specimen without attempting a description.

"*Postscript.* — The larve was probably a larve of a neuropterous insect, which often has false legs along the abdomen; but if so, it is surprising that there are no legs to the corselet, neuropterous larves having three pairs."

The "rude sketch" to which Dana refers was published as fig. 1 of the Ichnology, and later on a reduced scale as fig. 1164 of Dana's "Manual of Geology." Le Conte confirmed Dana's reference of the insect to the Neuroptera, placing it within the family Ephemeridæ, which induced Doctor Hitchcock to change the name of the fossil to *Palephemera mediæva.*

Scudder first decided (Geol. Mag., v, pp. 218-220) that the insects were coleopterous larvæ, and suggested later that they "reminded one of some Cebrionidæ," but said that the only larva of that group whose history is known "lives on the roots of plants and would not be likely to occur in such a deposit as that in which these remains were found." Dr. A. S. Packard (1890) in turn expressed the opinion that they were "aquatic coleopterous larvæ, belonging perhaps near the family Heteroceridæ." Scudder later had the opportunity to examine all the remains in the museums at Amherst College and at Yale, some hundreds altogether, and came to the conclusion (1886) that, while they present considerable variation, the specimens all pertain to one species to which of course Hitchcock's first name should apply. Scudder's description gives the following main characteristics: —

Number of segments apparently thirteen, of which one constitutes the head, and three, sometimes very obscurely differentiated, the thorax. There seem at times to be lateral anterior lobes to the head, always separated from it by a more or less well marked suture, which are probably inferior appendages showing only when projected forward. The head is rounded, usually a little broader at the base than in the middle, slightly broader than long, the front well rounded.

The three thoracic segments are almost invariably larger, generally considerably broader than the others, and are often distinctly differentiated as a separate region, both by their breadth, greater than that of the uniform segments behind, and by the slight forward inclination of their sides. Usually the middle thoracic segment is larger than the front thoracic segment, so that their relative size is II, I, III; but not infrequently the front one is the largest, and there are some cases where the broadest part of the body is behind the thoracic segments, and the order of breadth in the thoracic segments is III, II, I, which changes the whole aspect of the insect. In some instances the form reminds one of the larva of a longicorn beetle while the other extreme recalls some of the Silphidæ. An average or normal thoracic segment is about three times as broad as long, subquadrate, with very slightly concave front margin, and a little more distinctly convex hind margin, the sides well rounded, and the hinder angles more broadly rounded off than the front lateral angles, giving a slightly sublunate form to the entire segment. These segments are further marked by more or less distinct lateral marks, usually impressed, either angular or rounded, which are the only indications, if such they are, of appendages. Whatever they are, Scudder is emphatic in the statement that there is nothing else on a single specimen of those examined by him — many hundreds in number — which could be referred to legs (*vide infra* p. 52).

The abdominal segments invariably taper to some extent toward the tail; sometimes the tapering is scarcely visible on the anterior segments, and it is always more pronounced posteriorly, though here again there is variation. As a very general rule, the segments are quadrate, with very gently convex sides and slightly and equally rounded anterior and posterior angles; but in a few cases the anterior angles are considerably more rounded than usual, and the posterior angles, besides being square, are furnished with a faint posterior extension, bristle, or tapering cluster of hairs (it is impossible to say which, but the last is the most probable). This same posterior set of appendages may be seen more or less distinctly in some of the other specimens, where the segments have the posterior angle as rounded as the anterior.

" The surface of the abdominal segments is in general flat, but not quite uniform, at least on many specimens. There appear to be two kinds of inequalities, one of which from its infrequency and position seems to be accidental, perhaps due to pressure. This is seen . . . . in sharp lines close and parallel to the margin. The other, however, though often obscure, is too common to be so considered, and consists in a longitudinal series of slight ridges, laterally convex, and extending the whole length of the abdomen, dividing the segments into equal or subequal transverse thirds, of which the middle third is apt to be the largest. . . . . Besides these, there is nearly always some median mark of greater or less intensity, indicating probably the track of the alimentary canal. . . . It would appear tolerably clear that a slender alimentary canal, nowhere expanding into a well marked stomach, doubled sharply upon itself at or near the seventh abdominal segment, and again, by doubling at the hinder extremity of the fifth abdominal segment, resumed its former course, the whole of the sixth segment and at least a part of the seventh having therefore three sections of the canal passing through the middle. . . . . .

" It now remains to speak of the curious variations of the terminal or ninth abdominal segment and of its special appendages." This segment is generally " quadrate but well rounded, tapering and about two-thirds as large as the preceding joint. In some cases, however, ... it is very small, and its separation from the preceding joint hardly noticeable, while at the other extreme . . . . it is scarcely smaller than the preceding segment and longer, if anything, than broad. But the most interesting feature in this segment is the discovery in a few specimens . . . . of slender styles, a little shorter than the penultimate segment, directed backward and a little divergent; and a much shorter pair, or perhaps only projections of the pygidium, lying between the longer styles.

"As there is not a single specimen . . . . showing a lateral or even a partially lateral view, the insect could not have been cylindrical but must have been considerably flattened."

After comparing the characters of the larvæ of several coleopterous families and of the neuropterous families Perlidæ and Ephemeridæ, Scudder comes to the family Sialidæ, of which the larvæ are also aquatic. Speaking of these he says: —

"Here we find a considerably greater range of characteristics, so that it is not so easy to recognize a common facies among them. But we may note one or two characteristics by which they approach much more closely our fossil type. All the appendages — antennæ, legs, and (often) the cerci — are shorter and slenderer than in the two groups last mentioned. In some, the antennæ at least are comparatively insignificant. The mandibles in some are very stout, and, though long in all that are known, may well be believed to be capable of modification in this regard. The abdominal segments are provided with lateral filaments, projecting backward from the posterior outer angles. The appendages of the terminal segment vary very much, some having a single median style of considerable length, others a shorter lateral pair, in some cases furnished apically with recurved hooks. The objections to considering this as the most nearly allied group are the considerable size of the legs even when least developed, the great size of the head, which is at least as large as the segments behind, and the slight differentiation of the prothoracic segment shown at least in its larger size."

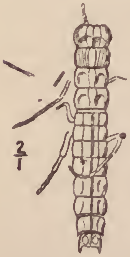

Fig. 1.— *Mormolucoides articulatus.* Twice nat. size. Original.

I have been fortunate in the extreme in finding upon two counterpart pieces of the typical black slate from Turners Falls, collected by T. M. Stoughton and now in the Yale Museum, a fairly well preserved individual of this most interesting larva, in which some of the thoracic legs and one antenna are present, and which compare very well with those of the Sialidæ. As preserved, the antenna of the left side is filiform, showing five segments of equal length. It is not, however, attached at the lateral angle of the head as in the larva of *Corydalis cornuta,* but the insertions of the two antennæ were separated by a distance of about one-third the total width of the head, which would seem to preclude the presence of large mandibles, unless they were, as appears true, beneath the head rather than between the antennæ as in *Corydalis.* The thoracic legs are relatively longer and more slender than in *Corydalis,* and one at least shows four distinct tarsal segments. The specimen unfortunately is somewhat ruptured, so that the abdominal region is displaced a little to the left, and the limbs partially detached from the body so that the hinder pair seem to arise from the second or third abdominal segment rather than from the metathorax. In my figure (fig. 1) I have tried to correct the dislocation of the body, but the legs are drawn as they appear, the posterior one of the right side being curved over the abdomen. In this individual the number of segments is in doubt, there being twelve distinctly visible and probably traces of a very narrow anterior abdominal one in addition. The prothorax differs from the other thoracic segments by slight longitudinal furrows, four or five on either side, while the meso- and metathoracic segments are characterized by a slight median ridge and paired lateral depressions. The larva under consideration is of average size (about 15 mm. long), and gives no very marked evidence of representing a different species, even though the thoracic appendages are preserved, while, except for the anal cerci, those of the abdomen are not, a reversal of the conditions often seen in other individuals.

These further observations give additional weight to Scudder's conclusion "that *Mormolucoides* is probably the larva of a sialidan neuropteron. It has special interest from the fact that it is the oldest known insect larva."

The recorded localities for this insect are all within the Turners Falls region: — Montague, the Horse Race at Gill, and Turners Falls itself.

Judging from the habits of the modern representatives of the family, their presence would seem to imply standing water of at least seasonal duration.

Phylum **MOLLUSCA**

The earliest allusion to a mollusc in the Connecticut valley is in the Ichnology (Hitchcock 1858, p. 6), in which a very brief description is given of a shell-like specimen found in the same sandstone with the fern *Clathropteris* from Mount Tom in Easthampton by Doctor E. Hitchcock, Jr. This is described as a "shell or mollusk — preserved, not petrified — which, although greatly injured, is allied, apparently, to the rudistæ of Lamarck, especially to the sphaerulites and hippurites. This family of shells on the eastern continent seems to be chiefly confined to the Chalk formation; and though the specimen is too much injured to have its genuine character determined, this fact gives plausibility to the opinion that the deposit containing it is newer than the Trias. As it is the only shell that has ever been found in the sandstone of this valley, I give a sketch of it. The original is now in Amherst College. See Plate v., fig. 2." The figure is a lithographic drawing from which it is impossible now to draw conclusions as to the true place of the fossil. It does bear some superficial resemblance to the Rudistæ, judging from the picture; but this group of shells is exclusively marine, which alone precludes the possibility of the reference of the specimen under consideration to that group, for it is in association with a possible fern and not far removed from a footprint locality containing *Eubrontes giganteus*. The locality lies beneath the main trap sheet. Judging from the figure, however, it seems to be inorganic, doubtless a weathered-out concretion.

Class **LAMELLIBRANCHIATA**

Family UNIONIDÆ

Genus **Unio**

Another discovery is that reported by Professor B. K. Emerson (1900, p. 58) as follows: —

" A few days ago my former assistant, Mr. Chas. S. Merrick, of Wilbraham, sent me a large slab of sandstone of a buff color, much stained by malachite, containing several indistinct casts of a unio-like bivalve.

" The shell seems to be one of those fresh- or brackish-water forms common in the Trias allied to the Unionidæ. It may be compared with the *Anoplophora lettica* Quenstedt (Pal., pl.

lxiii, fig. 28), and may be called *Anoplophora wilbrahamensis.* It is a distinctly unio-shaped shell, 38 mm. long, 18 mm. high, 7 mm. thick. The exterior is smooth with fine lines of growth. The mantle impression is quite deep as preserved on the central portion of the length. The beak rises very slightly and the hinge line is long and straight, and there is in the figure what seems to be the impression of a long posterior tooth, and above this a slight groove at the place of attachment of the ligament."

Through the courtesy of Professor Emerson this slab was sent to me for further study, and I referred the specimen to Professor Schuchert who has kindly made the following addenda: —

There are on the slab at least fourteen imperfect impressions representing at least two species of undoubted *Unio,* the type of Emerson's species being similar to *U. alatus.* It should hereafter be referred to as *Unio wilbrahamensis.*

The second species, which I have designated *U. emersoni,* is quite distinct from the first but is too imperfect to characterize. It is also unquestionably *Unio. Anoplophora,* Schuchert says, is probably always marine, and the shells in question are doubtless in fresh-water deposits. The slab, which is a portion of an ice-transported boulder, the parent ledge of which is probably unknown and therefore not necessarily as far south in the valley as Wilbraham, shows little trace of oxidation, and gives evidence of having been deposited in permanent waters, the bottom vegetation holding the oxygen from the iron and thus preventing the typical red color of iron oxide. The yellowish color may be due to oxidation of carbonate of iron. This conception of the habitat is in keeping with that of present day Unios. Wilbraham, being toward the eastern side of the valley, is therefore near the summit of the Newark series stratigraphically.

INVERTEBRATE TRAILS

The founder of the science of Ichnology, Professor Edward Hitchcock, seems to have been troubled by few rules of nomenclature, and as a consequence changed the names of his various species at will, whenever he thought a name inappropriate or misleading. As a result the synonymy of fossil footprints has been complicated to a marvelous degree.

It happens that the first invertebrate trails were named in a paper published by Hitchcock in 1848 (Fossil Footmarks of the United States), so that in these instances the nomenclature dates from that volume. The Ichnology (1858) and the Supplement (1865) by Hitchcock added to the series and changed certain of the names, but the final summary was given by Professor Charles H. Hitchcock in 1889, who added one more named species and two unnamed new species to the list.

The last-named author summarized the known species as follows: —

Hexapod Arthropoda, 8 genera, 24 species.

Inferior Arthropoda, including larval forms, and worms, 10 genera, 16 species.

Mollusca, 4 genera, 6 species.

Incertæ Sedis, 5 genera, 6 species.

This places the total number of invertebrates and questionable trails at fifty-two. In view of the number of undoubted vertebrate species known from the Newark system and the teeming numbers of living invertebrates, especially arthropods, compared with vertebrates, even under adverse climatic conditions, this number does not seem excessive. In fact, I imagine it may fall far short of the number of continental invertebrates of Newark time.

LIST OF SPECIES

The grouping is modified from that of C. H. Hitchcock, 1889.

Phylum **ARTHROPODA**

Class **INSECTA**

Genus **Acanthichnus** E. Hitchcock

Generic Characters. — "Tracks linear; in two parallel rows."

Acanthichnus cursorius E. Hitchcock

E. Hitchcock 1858, p. 150, pls. xxviii, fig. 1; xxxi, fig. 1.
Locality. — Turners Falls, Lily Pond.

Acanthichnus alternans E. Hitchcock

E. Hitchcock 1865, p. 14, pl. vi, fig.5.
Locality. — Lily Pond.
The type of this species was formerly referred to *A. cursorius.*

Acanthichnus alatus E. Hitchcock

E. Hitchcock 1865, p. 14, pl. vi, fig. 6.
Locality. — Not recorded.

In fig. 1 of Pl. vi there is shown a series of tracks which Hitchcock calls *A. cursorius* but in which a typical *cursorius* trail can be seen merging into that of *A. alatus*. It would seem, therefore, that the distinction between the two species cannot always be made.

Acanthichnus saltatorius E. Hitchcock

E. Hitchcock 1858, p. 151, pl. xxviii, figs. 4, 5.
Locality. — Turners Falls, Lily Pond.

Acanthichnus anguineus E. Hitchcock

E. Hitchcock 1865, p. 14, pl. vii, fig. 4.
Locality. — Lily Pond.

Acanthichnus trilinearis E. Hitchcock

E. Hitchcock 1865, pp. 14-15, pl. vi, fig. 11.
Locality. — Lily Pond.

Acanthichnus punctatus E. Hitchcock

E. Hitchcock 1865, p. 15, pl. vi, fig. 13.
Locality. — Unrecorded.

Acanthichnus rectilinearis E. Hitchcock

E. Hitchcock 1865, p. 15, pl. vi, fig. 2.
Locality. — Unrecorded.

Acanthichnus divaricatus E. Hitchcock

E. Hitchcock 1865, p. 15, pl. vii, fig. 10.
Locality. — Unrecorded.

Genus **Bifurculapes** E. Hitchcock

E. Hitchcock 1858, p. 152.

Generic characters. — " Four regular rows of tracks made in walking, which, when united, as they often are at the base, resemble small forks. Two additional rows sometimes visible."

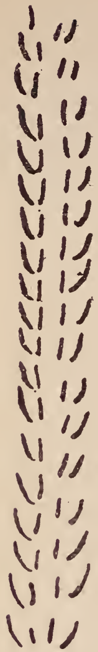

FIG. 2. *Bifurculapes laqueatus.* Nat. size. After Hitchcock.

Bifurculapes laqueatus E. Hitchcock

E. Hitchcock 1858, p. 153, pl. xxx, figs. 1-3.

Locality. — On Mr. Field's farm at Turners Falls.

Bifurculapes tuberculatus E. Hitchcock

E. Hitchcock 1858, p. 153, pl. xxx, fig. 4.

This species is eliminated by Hitchcock in the Supplement (1865, p. 15) "from the probability that the tubercles which are all of the track that remains, are in fact only the more persistent part of the original track; the little elevation of the mud, produced by the animal's tread, while the linear part has been worn away; for sometimes it remains."

At least two of the specimens mentioned in the original description are, in the catalogue prepared by C. H. Hitchcock and published in the Supplement, referred to *Acanthichnus cursorius.*

Bifurculapes curvatus E. Hitchcock

E. Hitchcock 1865, p. 15, pl. vii, figs. 2, 9.

Locality. — Lily Pond.

Bifurculapes scolopendroideus E. Hitchcock

E. Hitchcock 1858, pp. 153-154, pl. xxvii, fig. 1.

Locality. — Turners Falls, below the cataract.

Bifurculapes elachistotatus E. Hitchcock

E. Hitchcock 1858, pp. 154-155, pl. xxix, fig. 4, pl. xxx, fig. 3.

Locality. — Turners Falls, Lily Pond.

Genus **Lithographus** E. Hitchcock

E. Hitchcock 1858, p. 156.

Generic characters. — "Hexapod; longest tracks in parallel rows, and between the shorter ones. Outer track crooked, so as to become even forked. Inner one shortest."

In 1865, p. 15, Hitchcock says:

"I have become convinced that the *Copeza* [*vide infra*] and *Lithographus* of the Ichnology are so nearly alike that they may be united. I propose to drop *Lithographus* and retain *Copeza.*"

Even if this synoymy were proven, which I doubt, Hitchcock should have retained the name *Lithographus,* as it is, of the two, the one first described in the text. The name is therefore revived.

Lithographus hieroglyphicus E. Hitchcock

E. Hitchcock 1858, pp. 156-157, pl. xxix, fig. 3, pl. xxvii, fig. 2.

Copeza propinquata E. Hitchcock 1865, p. 15. Here Hitchcock says:

"The *C.*[*opeza*] *triremis* is remarkable for the great width of the trackway. The *Lithographus hieroglyphicus,* Plate vii, figs. 1 and 10, has one not half as wide! and I would call the species *Copeza propinquata.*" This new specific name of course cannot be retained.

Locality. — Field's farm, Turners Falls.

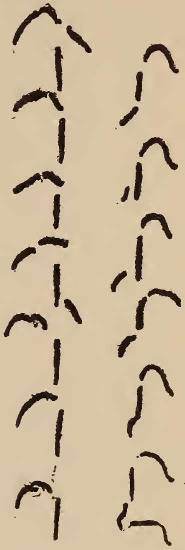

Fig. 3.—*Lithographus hieroglyphicus.* Nat. size. After Hitchcock.

Lithographus cruscularis E. Hitchcock

E. Hitchcock 1858, p. 157, pl. xxix, fig. 4, pl. xxx, fig. 3.

Copeza cruscularis E. Hitchcock 1865, p. 15.

Locality. — Turners Falls.

Lithographus punctatus (E. Hitchcock)

Copeza punctata E. Hitchcock 1865, p. 15, pl. vi, fig. 14. I should call this species *Lithographus,* as the additional markings are *without* the longitudinal lines as in *Lithographus,* not within as in *Copeza.*

Locality. — Lily Pond.

Genus **Copeza** E. Hitchcock

E. Hitchcock 1858, p. 159.

Generic characters. — "Feet six; the tracks arranged in triple rows on each side of the median line; the principal track being placed at right angles to that line, as oars on the sides of a boat when in use."

The main distinction between this genus and *Lithographus* seems to be that in the latter the oblique markings are outside of the longitudinal ones whereas in *Copeza* they are within.

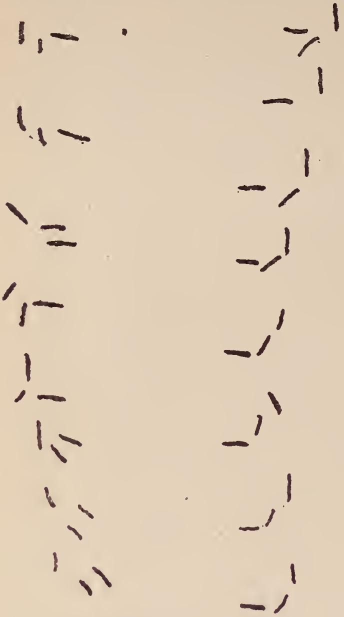

FIG. 4.— *Copeza triremis*. Nat. size. After Hitchcock.

Copeza triremis E. Hitchcock

E. Hitchcock 1858, pp. 159-160, pl. xxxi, fig. 4.

Locality. — Field's farm, Turners Falls.

This, the type species of the genus, is the only one showing the generic characters as emphasized above. As Hitchcock says, it seems more like an insect than any other tracks he has described.

Genus **Hexapodichnus** E. Hitchcock

E. Hitchcock 1858, p. 158.

Generic characters.— "Tracks arranged by threes, in rows on each side of the median line; the inner tracks running nearly parallel to that line. Outer tracks parallel, or diverging outwards. Alternate on opposite sides of the median line."

Hexapodichnus magnus E. Hitchcock

E. Hitchcock 1858, p. 158, pl. xxix, fig. 7.
Locality. — Turners Falls, Lily Pond.

Hexapodichnus horrens E. Hitchcock

E. Hitchcock 1858, pp. 158-159, pl. xxx, fig. 1.
Locality. — Field's farm, Turners Falls.

Genus **Conopsoides** E. Hitchcock

E. Hitchcock 1858, p. 152.

Generic characters. — "Tracks in three, and probably four rows; divergent from the median line. Foot blunt at its anterior part, and so striking the mud in walking as to elevate a tubercle."

Conopsoides larvalis E. Hitchcock

E. Hitchcock 1858, p. 152, pl. xxix, fig. 6, pl. xxx, fig. 4.
Locality. — Field's farm, Turners Falls; Wethersfield, Conn.

Conopsoides curtus E. Hitchcock

E. Hitchcock 1865, p. 15, pl. vi, fig. 4.
Locality. — Turners Falls, Lily Pond.

Genus **Harpepus** E. Hitchcock

E. Hitchcock 1865, p. 16.

Generic characters. — One, sometimes two, rows of tracks show a delicately curved foot, one end of which forms a raised and blunt extremity on the track, which may represent the handle of a minute sickle proceeding from it.

Harpepus capillaris E. Hitchcock

E. Hitchcock 1865, p. 16, pl. vii, fig. 6.
Locality. — Lily Pond, Turners Falls.

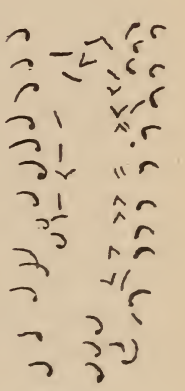

Fig. 5. — *Harpepus capillaris.* Nat. size. After Hitchcock.

Genus **Sagittarius** E. Hitchcock

E. Hitchcock 1865, p. 16.

Generic characters. — "Two parallel rows of delicately curved tracks, with their concave sides towards each other, looking like so many small bows."

Sagittarius alternans E. Hitchcock

E. Hitchcock 1865, p. 16, pl. vi, fig. 3, pl. xviii, fig. 5.
Locality. — Turners Falls, Lily Pond.

ARTHROPODA

Incertæ Sedis

Genus **Lunula** E. Hitchcock

E. Hitchcock 1865, p. 17.

Generic characters. — Track consists of a narrow axis, on both sides of which are lunate impressions, extending laterally. The front part of the track makes a much deeper impression than the posterior part, which shades off into the subsequent track.

This track Hitchcock believed to have been formed by a myriapod, but it may have been formed by a phyllopod crustacean such as *Apus* which I have seen in great abundance within the margins of pools of standing water in arid eastern Wyoming. The Apodidæ in their known range from the Lower Cambrian to the present are geologically possible.

Lunula obscura E. Hitchcock

E. Hitchcock 1865, pp. 17-18, pl. ii, fig. 6.

Locality. — Turners Falls, on fine red micaceous shale.

Genus **Pterichnus** E. Hitchcock

Acanthichnus (in part)

E. Hitchcock 1865, p. 17.

Generic characters. — Two rows of tracks usually quite numerous, turned outward at an angle of 15° to 20° from the median line.

Probably a myriapod.

Pterichnus tardigradus E. Hitchcock

Acanthichnus tardigradus E. Hitchcock 1858, p. 151, pl. xxviii, fig. 1.

Pterichnus centipes E. Hitchcock 1865, p. 17.

This is another instance of a total change of name by Hitchcock when his opinion of the animal's relationship was altered. The new generic name *Pterichnus* can stand, but the older specific name *tardigradus* of course has priority and must be used.

Locality. — Turners Falls, Lily Pond.

Genus **Hamipes** E. Hitchcock

E. Hitchcock 1858, p. 150.

Generic characters. — Two paired rows of impressions "curved inward, so as to be somewhat hook-shaped."

Large for an insect trail, but doubtless arthropodan.

Hamipes didactylus E. Hitchcock

E. Hitchcock 1858, p. 150, pl. xxv, fig. 8.

Locality. — Field's farm, Turners Falls, Lily Pond.

Genus Sphærapus E. Hitchcock

E. Hitchcock 1858, p. 164.

Generic characters. — "Trackway consisting of a furrow, in the bottom of which are two rows of [hemi-] spherical impressions, as if made by tubercules, rather than the feet of the animal."

In discussing the nature of the animal Hitchcock goes on to say:

"In the autumn of 1857, I found numerous larvæ of an insect beneath the rock maple (*Acer saccharinum*) and feeding on its leaves, whose tracks, figured on Plate vii, fig. 33, so much resemble the trackway of the species of *Sphærapus,* that I concluded both must have been produced by the same class of animals. Hence I placed *Sphærapus* among the Insects. But if we recur to a principle of paleontology . . . . that what are now larva forms typify extinct adult forms, we ought to look among existing adult forms to find the place of those ancient forms that correspond to existing larva forms. If so, we are led more probably to the Annelids than the insects for the place of the Sphærapans. For some existing Annelids have 'tubercles arranged in pairs along the under side of the body, which serve the purposes of feet.'"

I do not know what the larva may have been but the presumption is that it was a lepidopterous caterpillar of some sort and the Lepidoptera are not known before the Tertiary. A. S. Packard, however, in discussing (1890, p. 500) the primitive caterpillar says:

"The generalized or primitive form of the first caterpillar was, then, like that of Tineid larvæ in general, and was an external feeder, rather than a miner. The body of this forerunner or ancestor of our present caterpillars (which may have lived late in Carboniferous times, just before the appearance of flowering plants and deciduous trees), was most probably cylindrical, long and slender. Like the Panorpid larvæ, the thoracic and abdominal legs had already become differentiated."

Both the Panorpidæ and the Phryganeidæ (caddice flies) are known from the Trias and Jura, and the supposition has been advanced that the Lepidoptera and the Phryganeidæ are related, at least through a common ancestry. It would therefore be perfectly within the possibilities to account for the trail of *Sphærapus* as that of the larva of one of these forms, though not necessarily lepidopterous.

Sphærapus larvalis E. Hitchcock

E. Hitchcock 1858, p. 164, pl. xxviii, fig. 2.
Locality. — Field's farm, Turners Falls.

Sphærapus magnus E. Hitchcock

E. Hitchcock 1858, pp. 164-165, pl. xxviii, fig. 3.
Locality. — Turners Falls, on hard red shale.

Genus **Grammepus** E. Hitchcock

E. Hitchcock 1858, p. 155.

Generic characters. — " Tracks arranged in two parallel rows, the principal ones forming almost continuous lines, parallel to the line of direction. The two other tracks short, lying outside, and forming various angles with the median line."

These are evidently trails of some sort, but judging from Hitchcock's figures there seems to be but little regularity or serial repetition of the markings. They may be arthropod but one cannot be positive.

Grammepus erismatus E. Hitchcock

E. Hitchcock 1858, pp. 155-156, pl. xxix, fig. 1.
Locality. — Field's farm, Turners Falls.
Classified by C. H. Hitchcock (1889) as Hexapod.

Grammepus unordinatus E. Hitchcock

E. Hitchcock 1858, p. 156, pl. xxix, fig. 2.
Locality. — Field's farm, Turners Falls.

In his original description of this species Professor Hitchcock says:

" It may be doubted whether this species is worth giving, as we have but a single specimen, which, though distinct, is not all we could wish. I doubt whether this animal belongs to the genus *Grammepus,* because it shows only one row of tracks. But the impressions have a good deal of resemblance to those of the *Grammepus erismatus,* and I leave the two together until further light is obtained."

In 1865 (pp. 19-20) Hitchcock evidently thought sufficient further light was obtained to warrant a removal of this species from the genus *Grammepus* to a new one, *Ampelichnus,* but it is referred to a group of "specimens of doubtful origin and character." Hitchcock's further remarks are as follows:

"This genus is more obscure than the last [*Grammichnus*]. It consists on the track of grooves rarely more than a quarter of an inch, sometimes half an inch long, about the twentieth of an inch broad, arranged somewhat in a rachis form. Most usually these grooves are by pairs, as if made by a bipedate animal; but sometimes the number is greater, and the impression has the aspect of the stem and clusters of the grape; and hence the name (ἄμπελος, a vine)." Not only was the species removed to this new genus but a new specific name "*sulcatus*" given as well.

Genus **Stratipes** E. Hitchcock

E. Hitchcock 1858, p. 149.

Generic characters. — "Animal's feet perhaps didactylous; spread out in walking nearly at right angles to the line of direction." This is a very large trail 19 to 20 inches between the rows of impressions and 27 inches for the entire width of the trackway. The paired impressions are evenly spaced; but one may readily question whether the foot was didactylous, or whether as Hitchcock says the two digit-like impressions may not have been made by the fore and hind feet. A large enough crustacean to make such a trail seems to be out of the question in terrestrial waters. Hitchcock says: "But if this were not a giant crustacean, I know not what he was, and will not multiply words about him," and this seems to express the present state of our knowledge after the lapse of more than half a century.

Stratipes latus E. Hitchcock

E. Hitchcock 1858, pp. 149-150, pl. xlix, fig. 4.

Locality. — Field's orchard, Turners Falls.

The unique type slab which is No. 13/4 of the Amherst collection shows evidently a surface below that upon which the animal walked; and, as it is somewhat obscure in outline, may well give a somewhat erroneous idea of the actual track.

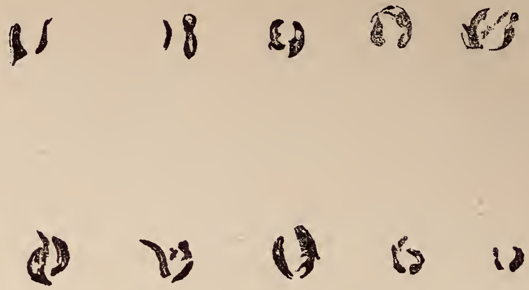

Fig. 6.—*Stratipes latus*. Nat. size. After Hitchcock.

Genus **Saltator** E. Hitchcock

E. Hitchcock 1858, p. 137.

Generic characters. — "Animals small; moving generally by leaps." The two species united under this head have little in common except for the apparent method of progression, and may have been made by very different animals, but the evidence is insufficient to separate them.

Saltator bipedatus E. Hitchcock

E. Hitchcock 1858, p. 137, pl. xxiv, fig. 8, pl. li, fig. 7.

Locality. — Turners Falls, probably on Field's farm.

Saltator caudatus E. Hitchcock

E. Hitchcock 1858, p. 138, pl. xxiv, figs. 9, 10.

Locality. — Turners Falls, Lily Pond.

Phylum **VERMES**

The old term Vermes is used as being more non-committal than Annelida. One cannot be sure that in every case the following track-makers were oligochete annelids though doubtless some were.

Genus **Herpystezoum** E. Hitchcock

Unisulcus

E. Hitchcock 1848, p. 245.

Generic characters. — "Track a curved or looped furrow, of various sizes."

The name of this genus was afterwards changed in the Ichnology (1858, p. 160) to *Unisulcus,* with the following definition: "Trackway a continuous single groove." There is no sign of the impressions of appendages and the trail seems to have been that of a worm-like form, probably an annelid.

Herpystezoum marshii E. Hitchcock

E. Hitchcock 1848, p. 246, pl. xvii, fig. 1.

Unisulcus marshi E. Hitchcock 1858, p. 160, pl. xxvi, fig. 1, pl. xlix, fig. 1.

Locality. — Turners Falls; Portland, Conn.

Herpystezoum minutum E. Hitchcock

E. Hitchcock 1848, p. 246, pl. xvii, fig. 2.

Unisulcus minutus E. Hitchcock 1858, p. 161, pl. xxvi, fig. 3.

Locality. — Turners Falls.

Herpystezoum intermedium (E. Hitchcock)

Unisulcus intermedius E. Hitchcock 1858, p. 161, pl. xxvi, fig. 2.

Locality. — Turners Falls.

Herpystezoum magnum (C. H. Hitchcock)

Unisulcus magnus C. H. Hitchcock 1889, p. 122.

Locality. — Milford, N. J.

Genus **Halysichnus** E. Hitchcock

E. Hitchcock 1858, p. 162.

Generic characters. — "Trackway with ridges on each side; as if the animal had ploughed its way through the mud instead of gliding over the surface; crossed at intervals by depressions, giving to the pathway the appearance of a chain."

Halysichnus laqueatus E. Hitchcock

E. Hitchcock 1858, p. 162, pl. xxvi, fig. 7.

Locality. — Turners Falls, Lily Pond.

Halysichnus tardigradus E. Hitchcock

E. Hitchcock 1858, p. 163, pl. xxvi, fig. 8.

Locality. — Field's farm, Turners Falls.

Genus **Cunicularius** E. Hitchcock

E. Hitchcock 1858, p. 163.

Generic characters. — "Animal constructing a covered pathway along the surface." "Trackway crooked and branched.

Branches terminating abruptly, and sometimes showing an accumulation of mud at the end." This creature, evidently a worm, made its burrows just beneath the surface in such a way that their impressions are found not only upon the stratum upon which the animal progressed but, unlike all other trails, upon the one above as well.

Cunicularius retrahens E. Hitchcock

E. Hitchcock 1858, p. 163, pl. xxvi, fig. 4.

Locality. — Turners Falls, below the cataract and near the trap; Middletown, Conn.

Genus **Cochlea** E. Hitchcock

E. Hitchcock 1858, p. 162.

Generic characters. — "Trackway somewhat resembling a double screw or spiral."

This genus C. H. Hitchcock classes as a mollusc, but it is difficult to conceive of the tracks as having been made by any molluscan animal within the narrow limits of those in terrestrial waters. The burrow branches in its coiling, which adds not only to its complexity but to the difficulty of an interpretation. It seems, however, more worm- than mollusc-like.

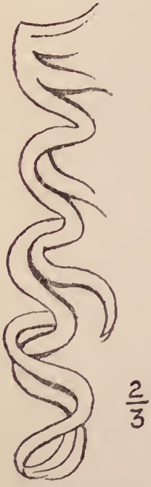

FIG. 7.— *Cochlea archimedea.* Two-thirds nat. size. After Hitchcock.

Cochlea archimedea E. Hitchcock

E. Hitchcock 1858, p. 162, pl. xxvi, fig. 9, pl. xlix, fig. 7.

Locality. — Turners Falls, Lily Pond.

Genus **Cochlichnus** E. Hitchcock

E. Hitchcock 1858, p. 161.

Generic characters. — "Trackway a continuous serpentine furrow, resembling a compressed corkscrew."

Cochlichnus anguineus E. Hitchcock

E. Hitchcock 1858, p. 161, pl. xxvi, fig. 6, pl. xxxvii, fig. 4.

Locality. — Field's farm, Turners Falls.

Phylum **MOLLUSCA?**

Under this head are placed some peculiar multiple trails the duplication of which seems to exclude them from the worms.

Genus **Bisulcus** E. Hitchcock

E. Hitchcock 1865, p. 18.

Generic characters. — Continuous paired grooves separated by a single ridge.

Bisulcus undulatus E. Hitchcock

E. Hitchcock 1865, p. 18, pl. iii, fig. 5.

Locality. — Field's orchard, Gill; Lily Pond, Turners Falls.

Genus **Trisulcus** E. Hitchcock

E. Hitchcock 1865, p. 18.

Generic characters. — Continuous grooves three in number separated by ridges which sometimes show slight protuberances like those of *Sphærapus.*

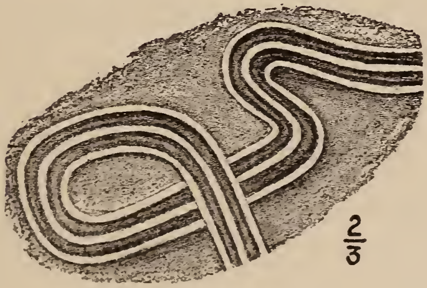

FIG. 8.— *Trisulcus laqueatus.*
Two-thirds nat. size. After Hitchcock.

Trisulcus laqueatus E. Hitchcock

E. Hitchcock 1865, pp. 18-19, pl. iii, fig. 4.

Locality. — Turners Falls, Lily Pond.

Impressions of Doubtful Origin and Character

Genus **Harpagopus** E. Hitchcock

E. Hitchcock 1848, p. 247.

Generic characters. — A succession of obliquely placed impressions, more or less elliptical in form, of very doubtful character. C. H. Hitchcock classes it with "Inferior Arthropods, etc."

Harpagopus dubius E. Hitchcock

E. Hitchcock 1848, p. 249, pl. xviii, fig. 3.

Locality. — Turners Falls; South Hadley canal.

Genus **Grammichnus** E. Hitchcock

E. Hitchcock 1865, p. 19.

Generic characters. — Single series of elongate impressions, five in number, repeated serially and placed at various angles. Hitchcock says:

" If the Roman capital A, or the Greek Alpha, was laid down in succession along a straight line and at right angles to the line, and the letters were connected by a sort of triple hyphen, it would give a tolerably good representation of the genus and species *Grammichnus Alpha.*" In some ways this suggests the preceding genus though more complex. It is possible that some rolling or rhythmically impressed object moved along by water might have made such a series of prints, analogous to the impression gotten from a cylindrical seal such as the ancients used.

Grammichnus alpha E. Hitchcock

E. Hitchcock 1865, p. 19, pl. iii, fig. 3.

Locality. — Unrecorded.

Genus **Climacodichnus** E. Hitchcock

E. Hitchcock 1865, p. 20.

Generic characters. — " Small, ladder-like rows of impressions, a good deal resembling the steps of the *Acanthichnus,* but more than sufficient to form the sides of the ladder, and extending past one another." The entire surface of the rock is always irregularly corrugated. The trails may be those of arthropods, but the nature of the corrugations is not understood.

Climacodichnus corrugatus E. Hitchcock

E. Hitchcock 1865, p. 20, pl. vii, fig. 5, pl. xiii.

Locality. — Turners Falls.

Genus **Ænigmichnus** E. Hitchcock

E. Hitchcock 1865, pp. 20-21.

Judging from the photographs figured by Hitchcock (1865, pl. xiv) and specimens in the Yale Museum, this genus seems to be not of animal origin, but rather the rolling over and over or rhythmical impression of a tree top or other vegetation by currents, which has impressed a great number of approximately parallel rows of lines, grooves, and depressions which Hitchcock has laboriously classified.

Ænigmichnus multiformis E. Hitchcock

E. Hitchcock 1865, pp. 20-21, pl. i, figs. 4, 5, pl. xi, figs. 1-6, pl. xii, figs. 1-4, pl. xiv.

Locality. — Ferry above Turners Falls; ferry at Turners Falls.

The Aquatic Vertebrates

Among the vertebrate fossils found in the Newark rocks of the Connecticut valley, two classes, fishes and reptiles, are represented by actual osseous remains; the latter surely, and probably the amphibia, are represented by their footprints. Whether or not the two higher classes, the birds and mammals, are represented is not yet proven; though mammalian remains are known from the Newark system in North Carolina, and the first authentic avian relics, those of *Archæopteryx,* already a long way along the road to avian perfection, coming as they do from the Upper Jurassic, would surely imply birds in some stage in their evolution during Newark time. The fishes have been studied exhaustively by Doctor C. R. Eastman for the Connecticut Geological and Natural History Survey[1], but in order to make my review of the Connecticut valley Triassic life complete I will insert the list of genera and species contained in Doctor Eastman's work.

The fish remains are almost entirely from the two general levels of black bituminous shale which also contain the plant relics, already enumerated, in varying profusion. Rarely are footprints found in juxtaposition to the fishes, and never, so far as I am aware, upon the fish-bearing shales themselves.

Geologically the shale bands are associated with the trap outflows, an anterior bed following 50 to 100 feet above the anterior trap sheet, and a posterior bed occurring about 100 feet below the posterior trap, the relationship of the shale and trap being in the one case the reverse of the other.

Geographically the fish localities are distributed from Turners Falls, Massachusetts, to Lake Saltonstall at New Haven, Connecticut, the principal localities for the anterior zone being:

Durham (west slope of Totoket), Connecticut.
Bluff Head, Connecticut.
Higby, Connecticut.

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[1] Eastman, C. R., 1911.

Berlin, Connecticut.
Southington, Connecticut.
? Southbury, Connecticut.

For the posterior zone:

Turners Falls, Massachusetts.
Sunderland, Massachusetts.
Chicopee Falls, Massachusetts.
Lake Saltonstall, Connecticut.
Durham (east of Pistapaug mountain), Connecticut.
Westfield, Connecticut.
South Bloomfield, Connecticut.
North Bloomfield, 1 mile east of Tariffville, Connecticut.
Rocky Hill, Hartford, Connecticut.

Besides these localities there is one in Middlefield, near the Laurel Brook Reservoir, which belongs to a horizon above the posterior trap sheet. One or two other localities of fossiliferous black shale have been reported, but are doubtful.

Of these localities by far the most important are Sunderland, Durham, and, of those without the limits of the valley, Boonton, New Jersey.

List of Species

Slightly modified from Eastman (1911)

Class **PISCES**

Subclass **TELEOSTOMI**

Order **CROSSOPTERYGII**

Family CŒLACANTHIDÆ

Genus **Diplurus** Newberry

Diplurus longicaudatus Newberry

Localities. — Durham, Conn.; Boonton, N. J.

Order **ACTINOPTERYGII**

Suborder **CHONDROSTEI**

Family CATOPTERIDÆ

Genus **Catopterus** J. H. Redfield

Catopterus gracilis J. H. Redfield

Localities. — Middletown, Middlefield, Durham, Southbury, Conn.; Sunderland, Mass.; Boonton, N. J.

Catopterus redfieldi Egerton

Localities. — Durham, Conn.; "apparently at other localities in the Connecticut valley and in New Jersey" (Newberry).

Genus **Dictyopyge** Egerton

Dictyopyge macrura W. C. Redfield

Locality. — Middletown, Conn.

Suborder **PROTOSPONDYLI**

Family SEMIONOTIDÆ

Genus **Acentrophorus** Traquair

(Generic position uncertain)

Acentrophorus chicopensis Newberry

Localities. — Chicopee Falls, Mass.; and, according to Hay, from New Jersey and Connecticut.

Genus **Semionotus** Agassiz

Palæoniscus (in part) and *Ischypterus* Egerton

Semionotus agassizii (W. C. Redfield)

Localities. — Sunderland, Mass.; Westfield and Middlefield, Conn.; Pompton and Boonton, N. J.

Semionotus alatus (Newberry)

Locality. — Boonton, N. J.

Semionotus braunii (Newberry)

Locality. — Weehawken, N. J., beneath the trap of the Palisades.

Semionotus elegans (Newberry)

Locality. — Boonton, N. J.

Semionotus fultus (Agassiz)

S. macropterus (W. C. Redfield), according to Hay.

Localities. — Boonton, N. J.; Sunderland, Mass.; and Durham, Connecticut.

Semionotus gigas (Newberry)

(Provisional species)

Locality. — Boonton, N. J.

Semionotus lenticularis (Newberry)

Locality. — Boonton, N. J.

Semionotus lineatus (Newberry)

Locality. — Boonton, N. J.

Semionotus micropterus (Newberry)

Locality. — Durham, Conn.

Semionotus minutus (Newberry)

(Doubtful species)

Locality. — Durham, Conn.

Semionotus modestus (Newberry)

Locality. — Boonton, N. J.

Semionotus ovatus (W. C. Redfield)

Localities. — Turners Falls and Sunderland, Mass.; Westfield and Middlefield, Conn.; and Boonton, N. J.

Semionotus parvus (W. C. Redfield)

(Doubtful species)

Localities. — Sunderland, Mass.; perhaps Durham and Westfield, Conn.; Boonton, N. J.

Semionotus tenuiceps (Agassiz)

S. latus (J. H. Redfield) according to Hay.

Localities. — For specimens described as *S. latus* — Sunderland, Mass.; Westfield, Middlefield and Durham, Conn.; and Pompton, Boonton and Plainfield, N. J.

Family EUGNATHIDÆ

Genus **Ptycholepis** Agassiz

Ptycholepis marshi Newberry

Locality — Durham, Conn.

We have therefore six genera and twenty species, of which six genera and thirteen species are found within the limits of the Connecticut valley, and six genera and probably thirteen species in the state of Connecticut, while New Jersey has produced four genera and sixteen species.

THE TERRESTRIAL VERTEBRATES

GENERAL DESCRIPTION

SKELETAL REMAINS

While the footprints constitute by far the great bulk of our evidence concerning terrestrial life of Newark time, the actual bone remains are more numerous than is generally supposed, though the majority of the finds have been of the most meagre description. W. M. Davis as late as 1898 (p. 35) speaks thus of the bone discoveries:

"The skeletons of these ruling inhabitants are exceedingly rare, only one having yet been discovered in Connecticut, but this, accidentally found in the abutment of a bridge at Manchester, is so well preserved that it excites the hope of finding more."

Davis refers to the story of the discovery of the type of *Ammosaurus major* Marsh, now preserved in the Yale Museum, which will be detailed below (*vide infra* p. 78).

Emerson and Loomis in 1904 (p. 377) in speaking of the discovery of *Stegomus longipes* say:

"The number of osseous remains [of the Connecticut valley] is limited to three dinosaur specimens and a portion of an Aëtosaurus-like carapace, called by Marsh, *Stegomus*."

As a matter of fact no fewer than three genera and five species of dinosaurs, one species of phytosaur and two species of aëtosaurs are known, making four genera and seven species, including that which Emerson and Loomis were describing at the time of their writing, while the actual number of bone remains from the Connecticut valley exceeds this record of different forms.

The northernmost locality where bones have been found is Greenfield, Mass., where a bone fragment presumably dinosaurian was discovered in 1875 (?) by Solon Wiley in a red sandstone quarry about one-half mile north of the village. This specimen is now preserved in the Yale Museum.

The next locality to the south is at South Hadley, Mass., "in a bowlder of Triassic sandstone which the glacier carried two or three miles, possibly, and deposited not far from the site of Mount Holyoke College" (Talbot 1911, p. 469). This discovery was made by Miss Mignon Talbot in 1910. Moreover in the

Proceedings of the Boston Society of Natural History, vol. iii, p. 340, 1850, mention is made of large vertebrates from East Windsor and South Hadley. Those from the former locality are discussed below; of the latter I can find no further trace either in the literature or in known collections unless "a few very imperfect fragments of the bones of a similar species [to *Thecodontosaurus (Megadactylus) polyzelus*] which were found earlier and are preserved in the museum" at Amherst, referred to by Emerson (*loc. cit.*), constitute the material alluded to. Material if I mistake not is also preserved in the Boston Society's Museum.

At Belchertown, Mass., Emerson (1898 A, p. 406) has "found many imperfect fragments of bone in the indurated sandstone of the contact zone of the easternmost volcanic core. . . . . This induration has prevented the percolation of water, which has doubtless carried away many bones formerly embedded in these coarse sandstones."

The next locality is at Springfield, Mass., where before the Civil War (1856?) "the bones were thrown out by a blast in excavating a well for the casting of a big gun at the water shops of the United States Armory, in the south part of Springfield, and only a part of the skeleton was preserved and presented to President Hitchcock" (Emerson 1898 A, p. 405).

The most southerly Massachusetts locality known to me is at Longmeadow. Emerson and Loomis (1904, p. 377) thus describe the discovery of this fossil:

"Some seven years ago, while removing the superficial layers of sandstone in the Hines Quarry, which is about a mile east of the village of East Longmeadow, Mass., Mr. G. B. Robinson found the small lizard-like specimen which is the subject of this paper. It occurred in a dense layer of red sandstone some ten feet below the surface and immediately above the thicker and softer layers which are used commercially for building stone. The discoverer removed the blocks containing the animal to his door yard, where they remained for about seven years exposed to the weather. They were seen by Mr. and Mrs. E. D. White, who obtained possession of them and brought the fossil to Springfield. Mr. and Mrs. White kindly placed this finely preserved fossil at our disposal for study and description." This specimen is still deposited in the museum at Amherst College.

In Connecticut the northernmost locality is that of East Windsor, the specimen now preserved at Yale having the distinction of being the first Triassic fossil found in the Connecticut valley the discovery of which is recorded. This find was made nearly a century ago, in 1818, and the first notice is contained in the *American Journal of Science,* vol. ii, 1820. Nathan Smith (1820, p. 146) thus described the discovery:

"Mr. Solomon Ellsworth, Jun., of East Windsor (Conn.), has politely favoured me with some specimens of fossil bones, included in red sand stone. Mr. Ellsworth informs me that they were discovered by blasting in a rock for a well; they were 23 feet below the surface of the earth, and 18 feet below the top of the rock. Unfortunately, before Mr. Ellsworth came to the knowledge of what was going on, the skeleton had been blown to pieces, with the rock which contained it, and several pieces of bones had been picked up, and then lost. . . . Mr. Ellsworth states that the bones were found in a horizontal position across the bottom of the well, as he thinks nearly to the extent of six feet."

This specimen, Cat. No. 2125 of the Fossil Vertebrate collection at the Yale Museum, I have identified as *Anchisaurus colurus* Marsh (*vide infra* p. 141).

Still another locality is that of Ellington, Conn., from which material was described and figured by E. Hitchcock in his "Final Report on the Geology of Massachusetts," 1841, pp. 503-504. The description of the discovery is as follows:

"Still more remarkable specimens, for which I am also indebted to Prof. Silliman, are shown on Plate 46, Figs. 69-73, of the natural size. These are made up entirely of fine reddish sand; and yet, their resemblance to bones is too obvious to be mistaken. . . . . . .

"These specimens were presented to Professor Silliman by a son of Hon. John Hall, of Ellington; a town that adjoins East Windsor. In answer to my enquiries, Judge Hall informs me, by letter, that the specimens were found at two places in Ellington; neither of which is more than 2½ miles from the locality already described in East Windsor."

These relics were at best only the casts of bones formed by the infiltration of sand into the place where bones had lain. I have been unable to trace them if indeed they exist to-day, but they seem to have been of dinosaurian origin.

By far the most notable bone locality in the valley is at Manchester, the place of origin of the important type specimens of *Anchisaurus colurus, A. solus* and *Ammosaurus major,* all of which, described by Professor Marsh, are preserved in the Peabody Museum at Yale. From Professor Marsh's notes I extract the following:

These specimens were found in the quarry of Mr. Charles O. Wolcott about one mile north of Buckland station in a layer about two and one-half feet in thickness, and, as the quarry was then worked, somewhat above the level of the roadway.

The first specimen, the *Ammosaurus major,* was found in 1884, and before its value was recognized the rock containing the skull and fore quarters was built into the abutments of a bridge over Bigelow brook, South Manchester. When the block containing the hind quarters was taken out, it was saved by Mr. Wolcott, and news of its discovery sent to Professor Marsh by Charles H. Owen, of Buckland, by whose aid and that of T. A. Bostwick the specimen was purchased. Subsequent earnest effort failed to secure the anterior portion.

The second saurian, *Anchisaurus colurus,* was found in the same layer, twenty feet south, in a large block of sandstone. The portion exposed showed the scapula and humerus and this had been the outer surface of the quarry for a long time. There was no record of when the adjoining block had been removed. Part of the large block was split off at New Haven, and this smaller piece contained the head and part of the neck. The rest of the skeleton (except one fore leg, one hind leg, the ends of the ischia, and the tail) was subsequently found in the main block.

The third saurian, *Anchisaurus solus,* was found at the same time as No. 2, in two small blocks which were subsequently fitted together. It was about two feet higher than, and about fifteen feet southeast of the previous specimen. This third specimen is nearly entire.

Saurian No. 4. During a visit to this quarry, September 24, 1894, three and a half years after the other specimens were received at New Haven, Professor Marsh found in essentially the same layer a large rib, quite perfect, and probably pertaining to an animal somewhat larger than any of the above. There is unfortunately no record of the receipt of this rib at New Haven.

On the west side of the valley and therefore, owing to the eastern dip of the Triassic strata, at a much lower geological level, another locality was discovered in the town of Simsbury. This specimen, consisting of a single bone, was found in the quarry of Orestes Wilcox, half a mile southwest from the station at Simsbury. It was designated as the type specimen of *Rutiodon (Belodon) validus* by Marsh (*vide infra* p. 109), and was received in the Yale Museum November 19, 1888.

The last locality in the valley is at Fair Haven, actually within the limits of the municipality of New Haven. The specimen was found in the quarry of Freeman Clark, not far from the Ferry Street bridge over the Quinnipiac river, and consists of the impression of the dorsal armor plates with no trace of actual bone. The specimen constitutes the type of *Stegomus arcuatus* Marsh and is preserved in the Yale Museum.

Thus it will be seen that at least eleven authentic localities in the Connecticut valley have produced vertebrate remains other than footprints, eight of the remains apparently of dinosaurs and three unquestionably of other reptiles (phytosaurs); of these nine are from near the summit of the Newark series geologically, while two, that of Simsbury and that of Fair Haven, are below the extrusive trap and therefore at a very much lower level. The dinosaurs and *Stegomus longipes* are from the newer, the *Rutiodon* and *Stegomus arcuatus* from the older rocks.

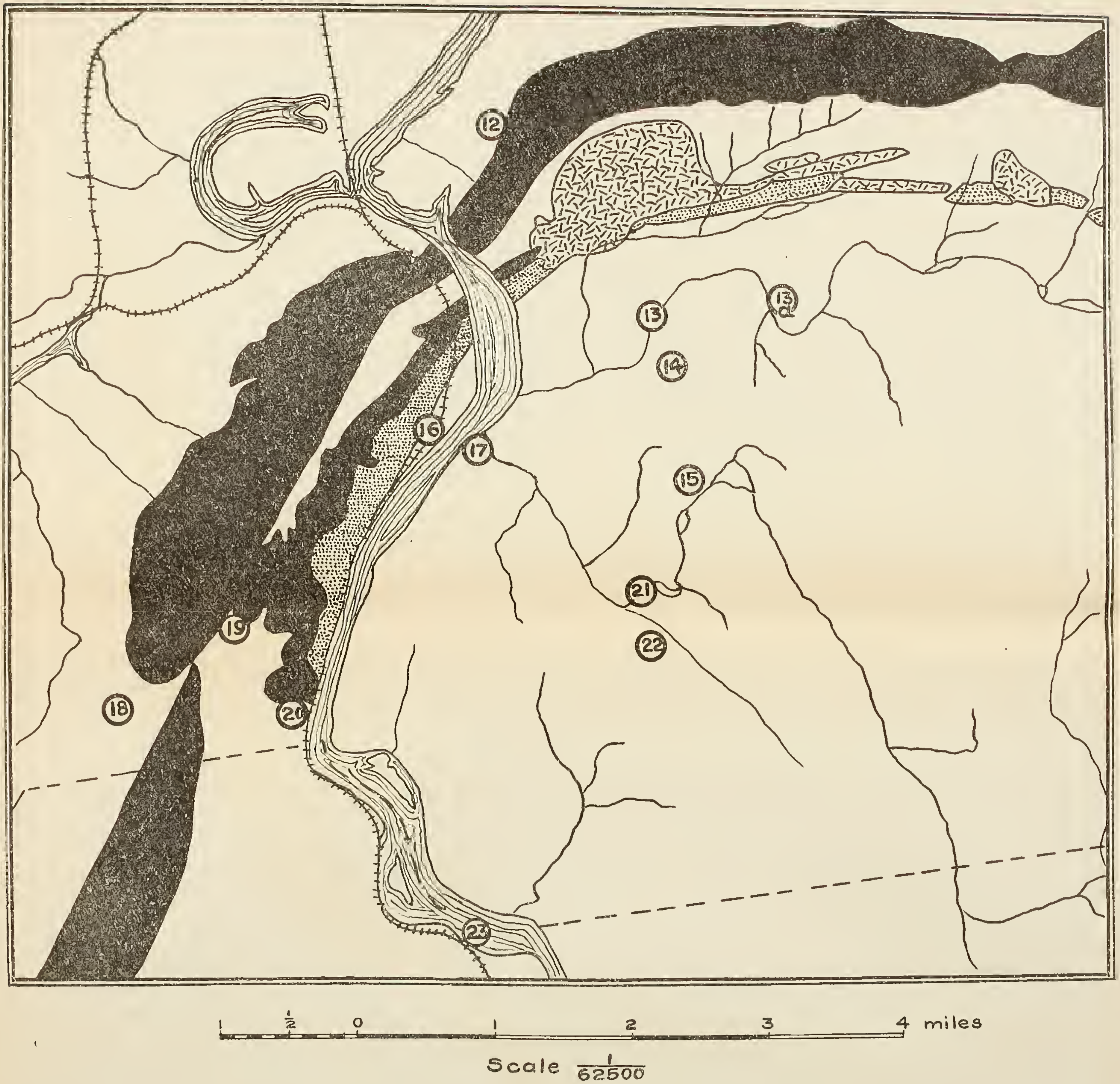
New Jersey has thus far been less prolific of actual bone from the Newark system though much material of later age has been brought to light. The Yale Museum contains a specimen of *Rutiodon* of undetermined species from the Belleville quarry just north of the city of Belleville (Edwards, *Amer. Jour. Sci.*, (3) l, 1895, p. 346). This specimen, consisting as it does of a portion of a jaw without the teeth, was said by Edwards to "look like *Dromatherium sylvestre* of Emmons." It is quite evident that Edwards never saw the minute jaw of the mammal *Dromatherium* or he would never have made such a comparison. Another fragment of bone from the sandstone quarries at Belleville, "too imperfect for identification," is preserved in the museum at Columbia University.

The public press of 1910, notably the *New York Tribune* of December 22d, announced the discovery of a "dinosaur" on the west shore of the Hudson below the Palisades and opposite 155th Street, New York City. The mass of rock containing the skeleton was removed to the American Museum where it is now preserved. The specimen was discovered by two Columbia students about eight months before its removal. Geologically, it lies near the base of the entire Newark series, and is both geologically and anatomically not a dinosaur but rather a phytosaur, the species of which is new to science. (*Vide infra* p. 113.) The *Saint Nicholas* magazine for May, 1911, contains a description of this "dinosaur" with restorations of *Anchisaurus*, which further emphasizes the unwisdom of premature publication when identification is incomplete, since in this instance the error will be difficult to rectify in the public mind.

An abundance of material has been obtained from Upper Milford and Phœnixville, Pennsylvania, from which several species have been described as dinosaurs. Their reference to that order is not admitted by Huene (1906, p. 101), but the whole material, the bulk of which is now in the Cope collection at the American Museum, should be restudied before final judgment is passed. It is my impression, however, that the Pennsylvania localities represent an older faunal phase than the dinosaurs of the Connecticut valley. The characters of the matrix (Wheatley 1861) and the associated fossils point to very different environmental conditions from those of the New England and New Jersey areas, hence a discussion of the fruits of the Pennsylvania locality may very properly be postponed.

FOOTPRINTS

While fossil footprints vastly exceed in numbers and kinds the actual bones, they like the latter are confined to certain definite geological levels, so that, while evidence of an abundant fauna is given, it is for the most part a contemporaneous fauna confined to the closing act of the Newark drama.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GEOLOGICAL MAP OF VICINITY OF SOUTH HADLEY.

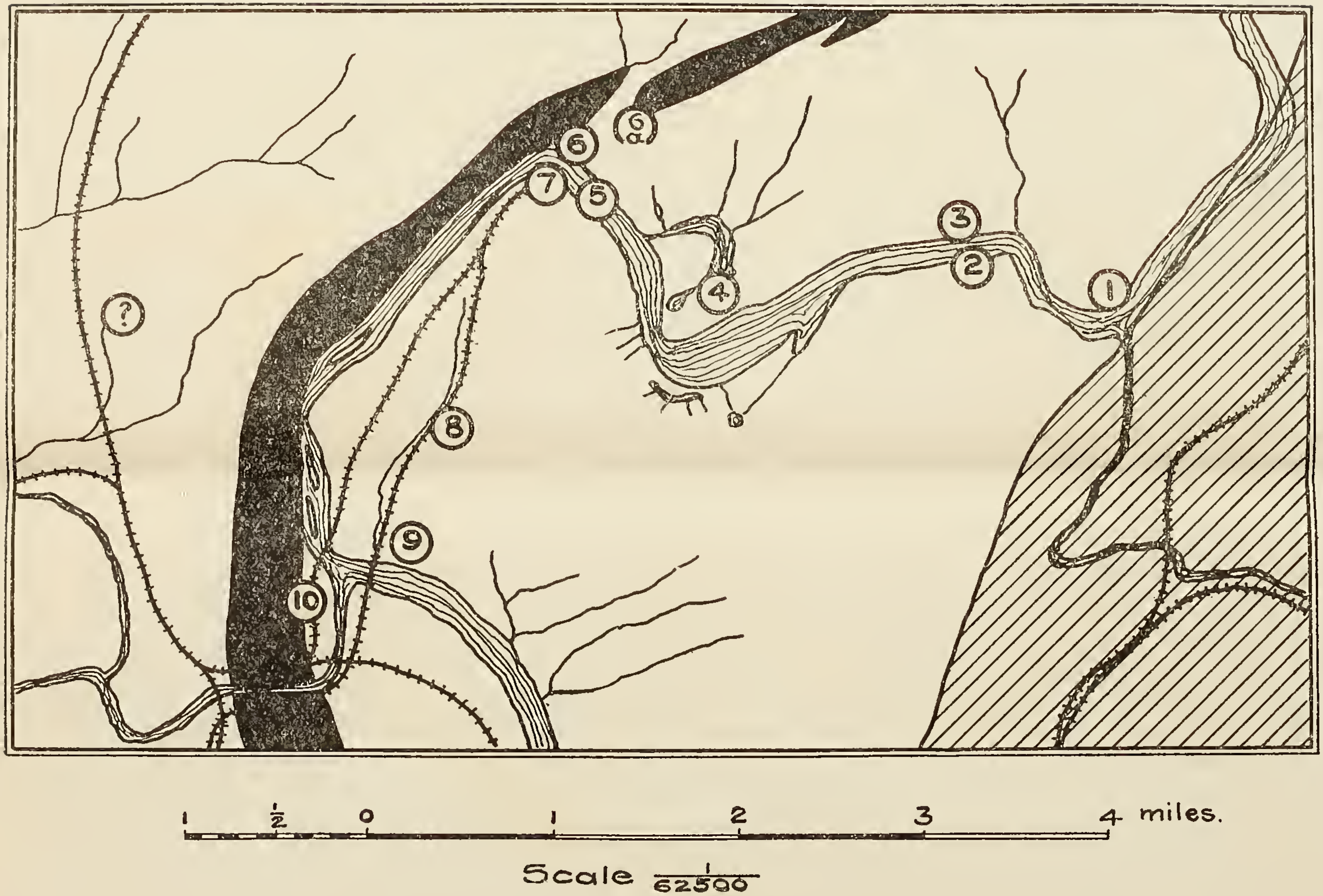
The numbers within the circles indicate the localities referred to in the text.

☐ Triassic Sedimentary Rocks.

■ Contemporaneous Sheets of Trap.

░ Tufa and Agglomerate.

▨ Volcanic Cores, and Dikes of Trap.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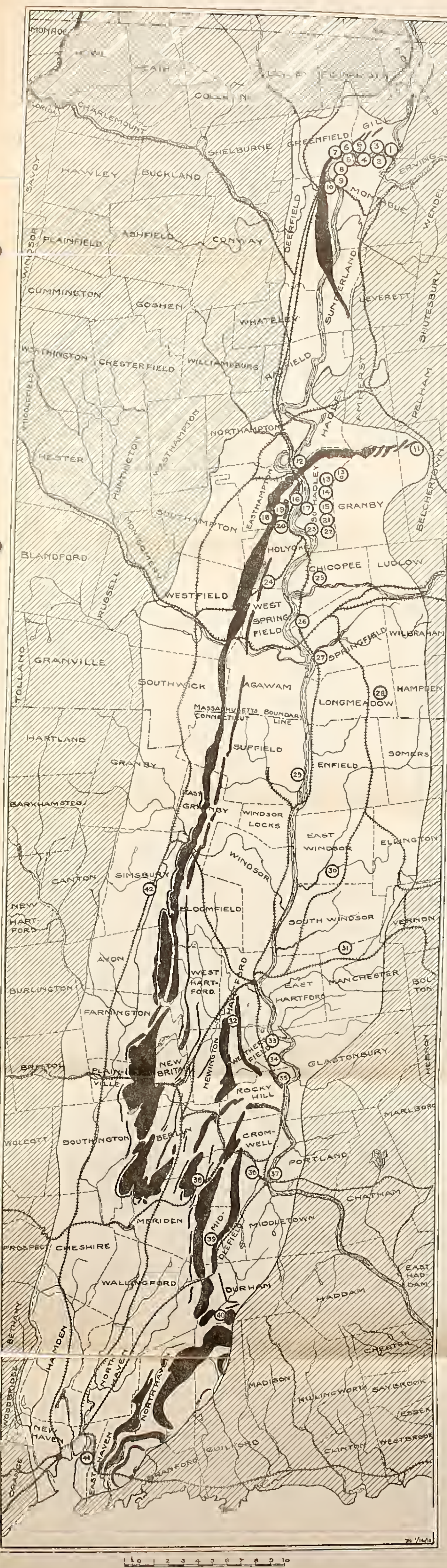
GEOLOGICAL MAP OF VICINITY OF TURNERS FALLS.

The numbers within the circles indicate the localities
referred to in the text.

▨ Pre-Triassic Crystalline Rocks.

☐ Triassic Sedimentary Rocks.

■ Contemporaneous Sheet of Trap.


MONROE
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COLRAIN
LEYDEN
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CHARLEMONT
GREENFIELD
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SHELBURNE
SAVOY
HAWLEY
BUCKLAND
ERVING
MONTAGUE
DEERFIELD
WINDSOR
PLAINFIELD
ASHFIELD
CONWAY
WENDELL
SUNDERLAND
LEVERETT
SHUTESBURY
CUMMINGTON
GOSHEN
WHATELEY
WORTHINGTON
CHESTERFIELD
WILLIAMSBURG
HATFIELD
AMHERST
PELHAM
HADLEY
MIDDLEFIELD
NORTHAMPTON
WESTHAMPTON
CHESTER
HUNTINGTON
SOUTHAMPTON
EASTHAMPTON
SO. HADLEY
GRANBY
BELCHERTOWN
MONTGOMERY
HOLYOKE
BLANDFORD
CHICOPEE
LUDLOW
RUSSELL
WESTFIELD
WEST SPRINGFIELD
SPRINGFIELD
WILBRAHAM
TOLLAND
GRANVILLE
SOUTHWICK
AGAWAM
HAMPDEN
LONGMEADOW
MASSACHUSETTS BOUNDARY LINE
CONNECTICUT
HARTLAND
SUFFIELD
SOMERS
GRANBY
ENFIELD
BARKHAMSTED
EAST GRANBY
WINDSOR LOCKS
EAST WINDSOR
ELLINGTON
WINDSOR
CANTON
SIMSBURY
NEW HARTFORD
BLOOMFIELD
SOUTH WINDSOR
VERNON
AVON
WEST HARTFORD
HARTFORD
EAST HARTFORD
MANCHESTER
BOLTON
BURLINGTON
FARMINGTON
NEWINGTON
WETHERSFIELD
GLASTONBURY
HEBRON
BRISTOL
PLAINVILLE
NEW BRITAIN
ROCKY HILL
MARLBORO
WOLCOTT
SOUTHINGTON
BERLIN
CROMWELL
PORTLAND
CHATHAM
MERIDEN
MIDDLEFIELD
MIDDLETOWN
PROSPECT
CHESHIRE
WALLINGFORD
DURHAM
HADDAM
EAST HADDAM
BETHANY
HAMDEN
NORTH HAVEN
CHESTER
WOODBRIDGE
MADISON
KILLINGWORTH
SAYBROOK
ESSEX
NEW HAVEN
EAST HAVEN
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GUILFORD
CLINTON
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Scale $\frac{1}{250000}$

GEOLOGICAL MAP OF CONNECTICUT VALLEY TRIASSIC AREA, SHOWING THE KNOWN LOCALITIES OF FOSSIL FOOTPRINTS AND FOSSIL BONES.

The numbers within the circles indicate the localities referred to in the text

▨ Pre Triassic Crystalline Rocks. ☐ Triassic Sedimentary Rocks ■ Contemporaneous Sheets of Trap

Bone and Footprint Localities

(indicated by numbers on the maps)

Massachusetts

1. North bank of Connecticut River, nearly opposite mouth of Millers River
2, 3. Horse Race
4. Lily Pond
5. Ferry above Turners Falls
6. North bank below Turners Falls
6a. Orchard, Gill
7. Montague Canal
8. Montague City
9. Marsh's Quarry, Montague
10. Greenfield
? Greenfield ? bone locality
11. Belchertown bone locality
12. Mt. Holyoke
13. Stream near Pliny Moody's
13a. Moody's Corner
14. Dickinson's Quarry, South Hadley
15. South Hadley
16. Smith Ferry
17. South Hadley, opposite Smith Ferry
18. Mt. Tom, west
19. Mt. Tom, east
20. Below Smith Ferry
21. South Hadley
22. South Hadley, *Podokesaurus* locality
23. Holyoke Dam
24. Holyoke
25. Chicopee Falls
26. Chicopee, near " Cabotville "
27. Springfield water shops, *Anchisaurus polyzelus* locality
28. Longmeadow, *Stegomus longipes* locality

Connecticut

29. Suffield
30. Ketch's Mills, East Windsor, bone locality
31. Manchester, *Anchisaurus* and *Ammosaurus* locality

32. "Rocky Hill," Hartford
33. Wethersfield Cove
34, 35. Wethersfield
36. Middletown
37. Portland
38. Higby
39. Middlefield
40? Durham
41. New Haven, *Stegomus arcuatus* locality
42. Simsbury, *Rutiodon validus* locality

Geographical Distribution

Geographically the tracks are distributed from Turners Falls to New Haven — nearly the entire length of the valley; but the greatest abundance of localities and the greatest profusion both of species and specimens are in the northern portion of the area, specifically around Turners Falls, and near South Hadley, Massachusetts.

Hitchcock in the Ichnology (1858, pp. 49-50) enumerates no fewer than thirty-eight quarries for fossil footprints and very few localities have been discovered since that time.

The more important localities, with the species each has produced, are as follows:

Massachusetts

Turners Falls area. — The northernmost locality is on the north bank of the Connecticut river, nearly opposite the mouth of Millers river. Species unrecorded.

Horse Race, Gill. — A very productive locality, from which are recorded the following species, alphabetically arranged:

Anchisauripus exsertus, minusculus, parallelus, sillimani, tuberosus
Argoides minimus
Batrachopus dispar, gracilior, gracilis
Corvipes lacertoideus
Eubrontes approximatus, divaricatus, giganteus
Grallator cuneatus
Otozoum moodii
Palamopus palmatus, rogersi

Sillimanius tetradactylus
Steropoides divaricatus, diversus, ingens
10 genera and 21 species.
Rock, gray micaceous sandstone and shale.

Lily Pond. — One of the most notable localities of all is that at the Lily Pond on the north bank of the Connecticut river ("Barton Cove" of the U. S. Geological Survey map), a locality that has produced not only a large proportion of vertebrate tracks but plant remains and nearly all of the known species of invertebrate trails as well. The rock is as a rule fine red and brown shale. The vertebrate species recorded are:

Anchisauripus exsertus, hitchcocki, minusculus, parallelus, sillimani, tuberosus
Anomœpus curvatus
Anticheiropus hamatus
Apatichnus circumagens, minor
Arachnichnus dehiscens
Argoides minimus
Batrachopus bellus, deweyi, gracilior, gracilis
Chelonoides incedens
Comptichnus obesus
Corvipes lacertoideus
Eubrontes approximatus, divaricatus, giganteus, tuberatus
Exocampe ornata
Gigandipus caudatus
Grallator cuneatus, cursorius, formosus
Harpedactylus gracilior
Hyphepus fieldi
Palamopus gracilipes, rogersi
Platypterna concamerata, digitigrada, gracillima
Plectropterna angusta, gracilis, lineans
Plesiornis pilulatus
Sauropus barrattii
Selenichnus breviusculus
Shepardia palmipes
Steropoides diversus, infelix, uncus
Tarsodactylus caudatus
In all 25 genera and 46 species.

Ferry above Turners Falls. — Another important locality is the "Ferry above Turners Falls," near where the bridge now crosses from Turners Falls village to Riverside.

The character of the sediment is red shale.

The species from this locality which I find recorded are:

Ammopus marshi (n. sp., *vide* p. 265)
Anchisauripus exsertus, sillimani
Anomœpus curvatus, gracillimus, intermedius, scambus
Apatichnus minor
Batrachopus deweyi, gracilis
Exocampe ornata
Grallator cuneatus, cursorius, gracilis
Orthodactylus sp.
Platypterna digitigrada, tenuis
Plectropterna gracilis
Plesiornis pilulatus
Selenichnus breviusculus
Stenonyx lateralis
Steropoides diversus, infelix

In all 14 genera and 23 species.

Ferry at Turners Falls.— Character of sediment, gray micaceous sandstone.

Known species referred specifically to this spot are:

Anchisauripus exsertus, minusculus, parallelus, sillimani
Anomœpus curvatus, gracillimus, intermedius, minimus, scambus
Apatichnus circumagens
Batrachopus gracilis
Grallator gracilis
Hoplichnus poledrus
Otozoum minus (n. sp., *vide* p. 225)
Selenichnus breviusculus

Number of genera 8; of species 15.

North bank below Turners Falls. — Character of sediment, gray shale.

Species recorded:

Ancyropus heteroclitus
Eubrontes giganteus

Exocampe arcta, ornata
Harpedactylus gracilior, tenuissimus
Helcura anguinea
Palamopus rogersi
Plectropterna gracilis, minitans
Sillimanius gracilior
Toxichnus inæqualis
Xiphopeza triplex

Number of genera represented 10; of species 13.

Turners Falls. — A great many specimens bear the general label of Turners Falls, which may belong either to the ferry at Turners Falls or to one of the other localities already specified. However, the building of the Turners Falls power dam at the cataract laid bare the river bed, and this, together with the attendant quarrying operations, proved a golden opportunity for the gathering of these interesting relics. The character of the sediment ranges from micaceous sandstone through gray to red and finally indurated shale.

The genera and species from this locality are:

Amblypus dextratus, sp. indet.
Anchisauripus exsertus, hitchcocki, minusculus, parallelus, sillimani, tuberatus, tuberosus
Ancyropus heteroclitus
Anomœpus curvatus, gracillimus, intermedius, isodactylus, scambus
Antipus bifidus, flexiloquus
Apatichnus circumagens, minor
Arachnichnus dehiscens
Argoides macrodactylus, minimus
Batrachopus bellus, deweyi, gracilior, gracilis
Cheirotheroides pilulatus
Corvipes lacertoideus
Eubrontes approximatus, divaricatus, giganteus
Exocampe arcta, minima, ornata
Gigandipus caudatus
Grallator cuneatus, cursorius, formosus, gracilis, tenuis
Harpedactylus crassus, tenuissimus
Helcura surgens

Hyphepus fieldi
Isocampe strata
Lagunculapes latus
Orthodactylus introvergens, linearis
Otozoum minus
Palamopus gracilipes, palmatus, rogersi
Platypterna concamerata, deanii, ? delicatula, recta
Plectropterna angusta, gracilis, lineans, minitans
Plesiornis pilulatus
Saltator bipedatus (vertebrate ?)
Sauropus barrattii
Selenichnus breviusculus, falcatus
Shepardia palmipes
Sillimanius gracilior, tetradactylus
Stenonyx lateralis
Steropoides divaricatus, diversus, infelix, uncus
Sustenodactylus curvatus
Tarsodactylus caudatus
Toxichnus inæqualis
Triænopus baileyi
Trihamus elegans
Xiphopeza triplex

This profuse fauna contains no fewer than 39 genera and 78 species.

Field's Orchard, Gill, Mass. — An important quarry at this locality has produced red shale and sandstone bearing imprints of the feet of

Amblypus dextratus
Anchisauripus exsertus, parallelus, sillimani, tuberosus
Anomœpus curvatus, gracillimus, intermedius, minimus, scambus
Apatichnus circumagens
Arachnichnus dehiscens
Argoides minimus
Batrachopus gracilis
Corvipes lacertoideus
Eubrontes platypus, tuberatus
Exocampe minima

Grallator cuneatus, cursorius, formosus, ?gracilis
Hyphepus fieldi
Orthodactylus ? introvergens
? Palamopus rogersi
Platypterna concamerata, digitigrada
Plectropterna minitans
Sauropus barrattii
Xiphopeza triplex

In all 18 genera and 30 species.

Montague. — Dexter Marsh's quarry, in southwestern part of Montague. Rock, reddish micaceous sandstone.

Anticheiropus pilulatus
Argoides minimus
? Sauropus barrattii
Steropoides divaricatus, diversus
Trihamus elegans

Five genera and 6 species.

Near Greenfield, Mass. —
Tarsodactylus expansus

Holyoke — Mt. Tom Range. — Outside of a few minor localities none is met with for a distance of about twenty miles, when one comes to the Holyoke-Mt. Tom range around which cluster a new group of footprint quarries. Here on the west side of Mt. Holyoke a few rods north of "Titan's piazza" in Hadley, an interesting locality is found, as it lies beneath the main trap sheet, not above as all to the north have done. This little quarry, like Bassett's quarry to the southwest of Mt. Tom in Easthampton, is of importance not from the profusion of species which it has produced, but from this fact of its lying beneath the main trap sheet and therefore, so far as I am aware, presenting one of the earliest records of dinosaurian existence on our continent.

The forms preserved are all carnivorous dinosaurs; from Mt. Holyoke, *Anchisauripus tuberosus* and probably *exsertus,* and from Mt. Tom, upon coarse sandstone, *Eubrontes giganteus,* one of the most majestic of Newark forms.

On the eastern slope of the Mt. Tom uplift, therefore on the west bank of the Connecticut, are at least three localities, one of which lies "between the ridges of trap near Ashael Lyman's, in Northampton" (Hitchcock 1858), at a level above those just mentioned but still below the level of the uppermost trap. This quarry has produced two genera and four species impressed upon gray sandstone: *Anchisauripus exsertus, tuberosus,* the first being one of the largest representatives of the genus, *Eubrontes tuberatus,* and *Eupalamopus dananus,* a quadrupedal form of doubtful affinities.

At Smiths Ferry at the higher geological level have been found the following impressed upon flagstone, often ripple-marked:

Anchisauripus exsertus, minusculus, sillimani, tuberosus
Eubrontes approximatus, divaricatus, giganteus
Grallator cuneatus, formosus
Platypterna concamerata
Steropoides divaricatus

Five genera and 11 species.

A small locality on the opposite side of the river has produced *Anchisauripus tuberosus,* one of the most common species, upon coarse sandstone bearing impressions of rain drops; while from South Hadley we have recorded:

Anchisauripus minusculus, parallelus, sillimani, tuberosus
Anomœpus curvatus, isodactylus, minimus
Apatichnus circumagens, minus
Batrachopus bellus
Eubrontes approximatus, divaricatus
Grallator cuneatus, tenuis
Steropoides divaricatus

In all 7 genera and 15 species.

Among the more specific localities within the town of South Hadley is Moody's corner, named for Pliny Moody, who first noticed the fossil footprints in so remote a year as 1802. This quarry is notable for having produced the type specimen of that most mysterious form, *Otozoum moodii,* in association with which were found:

Anchisauripus exsertus, minusculus, parallelus, sillimani, tuberosus
? *Ancyropus heteroclitus*

Anomœpus scambus
Apatichnus ? minor
Batrachopus deweyi
Grallator cursorius, formosus

Seven genera and 12 species.

The rock upon which the animals walked, a layer of red mud ¼ inch thick, could not be preserved, but the relief counterpart is composed of coarse reddish sandstone.

In the stream near Pliny Moody's upon coarse gray sandstone were found 3 genera and 4 species including the ubiquitous *Anchisauripus sillimani, Batrachopus ? deweyi,* and *Grallator formosus* and *tenuis.*

Dickinson's quarry, South Hadley, has specifically recorded:

Anchisauripus minusculus, sillimani, tuberosus
Anomœpus cuneatus, gracillimus, intermedius
Batrachopus deweyi
Eubrontes divaricatus
Grallator cuneatus, cursorius, tenuis

At least 5 genera and 11 species. It is highly possible that some of the other species referred to South Hadley may have come from this quarry.

Ashley Pond. — A quarry worked for commercial building stone situated to the west of the river in the town of Holyoke near Ashley Pond is said to have produced many footprints, quantities of which have been built into the foundations of the various mills in the city of Holyoke. One slab was shown me bearing two impressions which I identified as *Eubrontes giganteus* or *approximatus.* Of the other species no record is extant to my knowledge, as the locality has never been exploited scientifically, and as a rule when the commercially less valuable footprint layer is reached it is removed as speedily as possible.

Chicopee Falls. — At this locality, impressed upon hard black shale, were found:

Anchisauripus exsertus, sillimani
Anomœpus ? gracillimus
Argoides redfieldii
Grallator cuneatus, formosus

Plectropterna minitans
Plesiornis ? pilulatus
Polemarchus polemarchius

Seven genera and 9 species.

Chicopee. — Near the principal village of the town (formerly called Cabotville), some at least upon "slightly calcareous shale," were found:

Argoides macrodactylus
Plectropterna minitans
Polemarchus polemarchius
Sillimanius tetradactylus

In all 4 genera and species.

Connecticut

Crossing the border into Connecticut we come to still a third group of localities, all belonging to the higher geological level and all in proximity to the Connecticut river. The association of so many of the known localities with the present course of the river is probably due not so much to the absence of footprints elsewhere in the broad reaches of the valley as to the fact that in very few places away from the river is the Triassic sandstone exposed, it being for the most part covered with deposits of later geological age mainly of glacial origin.

Footprints have been found near Enfield bridge on the west bank of the river in Suffield, and at "Rocky Hill" in Hartford, but of the species I have found no record.

Wethersfield. — The northernmost important locality is at the cove at Wethersfield which also lies on the west bank of the river. Here the character of the rock ranges from red to brown shale, and the mud was as a rule so extremely soft when trodden upon by the Triassic denizens that the walls of many of the footprints have partially caved in, making a group of "leptodactylous" tracks which in my opinion are due rather to the state of plasticity of the substratum than to morphological characters of the feet which thus impressed themselves. For as a rule there is always a ratio between the plantar area of a creature's feet and his weight, varying in different species with the character of the ground upon which he habitually walks. These "leptodactylous" tracks being found practically nowhere else, it is inconceivable that they can be a special adaptation to a muddy surface which places the animal at so marked a disadvantage as that of sinking in at every step.

The Wethersfield Cove fauna includes the following, in addition to which there may be some wrongly included under "Wethersfield" without specific reference to the cove:

Ancyropus heteroclitus
Argoides macrodactylus, minimus
Eubrontes giganteus
Exocampe ornata
Grallator cuneatus
Platypterna deanii, delicatula, tenuis
Plectropterna minitans
Sillimanius gracilior, tetradactylus
Triænopus baileyi
Typopus gracilis
In all 10 genera and 14 species.

At Wethersfield, about two miles south of the cove, is another locality, and a third lies about as far beyond the second. At one or both of these places there have been impressed upon soft mud, which has since solidified into a red shale, the following species:

Anchisauripus exsertus, minusculus, sillimani, tuberosus
Ancyropus heteroclitus
Anomœpus cuneatus, gracillimus
Argoides macrodactylus, minimus
Comptichnus sp.
Corvipes lacertoideus
Eubrontes divaricatus, giganteus
Grallator cuneatus, cursorius, formosus, tenuis
Harpedactylus tenuissimus
Palamopus rogersi
Platypterna concamerata, deanii, delicatula, tenuis
Plectropterna elegans, gracilis, lineans, minitans
Plesiornis æqualipes (=? *Argoides minimus*), *quadrupes* (=? *Anomœpus intermedius*)
Sillimanius gracilior, tetradactylus

Steropoides diversus, infelix
Triænopus baileyi
Trihamus elegans, magnus
Typopus ? abnormis

In all 18 genera and 37 species are represented.

Portland. — One of the most notable localities for the interest attached to the species is at Portland and on the east bank of the river. Here are extensive quarries producing an excellent grade of building stone. Occasionally a level bearing footprints is found, though nearly all of the museum specimens preserved so abundantly at Wesleyan University as well as at the Hartford High School and at Yale are the counterparts, natural casts of the footprints themselves, preserved in high relief in coarse red sandstone.

Perhaps the most striking member of the Portland fauna is the immense *Otozoum moodii,* accompanied in great profusion by the tracks of *Anchisauripus sillimani,* as is also the case at Moody's corner, South Hadley. The complete faunal list is as follows:

Anchisauripus exsertus, sillimani, tuberosus
Batrachopus deweyi, gracilis
Cunichnoides marsupialoideus
Eubrontes giganteus
Grallator cuneatus, gracilis, tenuis
Hoplichnus equus (questionably of organic origin)
Isocampe strata
Otozoum moodii (= also *caudatum*)

There are thus recorded 7 genera and 12 species and 1 doubtful genus and species in addition.

Middletown and Middlefield. — From the neighborhood of Middletown,[1] comes the type specimen of *Anchisauripus sillimani* in high relief upon a slab of reddish micaceous sandstone which had been worn smooth on its upper surface as a flagstone in the streets of Middletown by the feet of two generations of men. It was dug from a quarry about two miles west of the city one hundred and thirty years ago, but the quarry has since produced so far as I can learn no other relics of a similar character. There are two counterpart slabs in the Redfield collection at Yale (Cat. No. 2126) labeled as coming from Middletown and bearing footprints which I have identified as those of *Grallator cursorius*. The precise locality, however, is in doubt. *Sauropus barrattii* is also reported to have been found at Middletown; this may, however, refer to the Middlefield slab mentioned below.

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[1] As the town of Middlefield was not separated from Middletown until 1866, some of the specimens reported from Middletown may have come from Middlefield.

A locality at Middlefield lying to the west of the easternmost trap ridge and therefore in the posterior shales, older than the long series of quarries along the river yet younger than those beneath the main trap sheet at Mt. Tom and Mt. Holyoke, has produced among other footprints the earliest record of the tracks of a plant-feeding dinosaur known to me. The list includes:

Anchisauripus exsertus, minusculus, sillimani
Anomœpus gracillimus
Eubrontes giganteus, tuberatus
Grallator cursorius

Four genera and 7 species. There have also been reported from Middlefield upon a sidewalk flagstone of doubtful origin:

Batrachopus gracilis
Sauropus barrattii

At Higby, footprints have been reported in the anterior shales by Davis (1898, p. 138), by whom Mr. S. Ward Loper was engaged to search for fossil fish localities "at the proper horizons for a considerable distance along the anterior and posterior valleys in the larger blocks, from Totoket Mountain northward to the gorge of the Farmington river at Tariffville. . . . . The drift cover proved a serious obstacle to success, but did not entirely defeat the search. After repeated failure to find outcrops in the long anterior valley from Tremont to the north end of Higby Mountain, the shales holding a few fish scales were discovered in a little ravine near the north-bounding fault, and on making an opening here, some of the characteristic fossils of the anterior shales were speedily found. Associated with them was a bed of sandstone containing *plentiful large reptilian footprints*" (italics mine).

No statement is made by Davis concerning the species of footprints, and I have been unable thus far to locate the material if it was collected. The species ought however to accord with those from Mt. Tom and Mt. Holyoke, that is, *Anchisauripus tuberosus,* possibly *A. exsertus* and *Eubrontes giganteus,* and I offer this as a prediction of their identity when they shall have been studied.

New Haven. — Footprints were also reported from near the quarry and presumably from the same geological level as that which produced the specimen of *Stegomus arcuatus* at New Haven. They were, however, neither preserved nor recorded; which seems little short of calamitous in view of the fact that not only were they at the farthest possible southern limit of the valley, but, lying as they did, within the limits of the lower series of coarse granitic sandstones (see geologic section opposite p. 20), they were far anterior in time to any of the footprints actually preserved.

Stratigraphical Distribution

The geologic sequence of the valley footprint localities is:

- Lower series, coarse granitic sandstone
  - New Haven, *Stegomus* quarry
- Anterior shales
  - Higby, Conn.
  - Bassett's quarry, southwest of Mt. Tom; Mt. Holyoke, Mass.
- Posterior shales
  - Middlefield, Conn.
- Between the ridges of trap near Ashael Lyman's in Northampton, Mass.
  - East face of Mt. Tom, Mass.
- Upper series, sandstones and shales
  - Portland-Wethersfield group, Conn.
  - South Hadley group, Mass.
  - Turners Falls group, Mass.
  - Of these the Portland locality and that at Moody's corner containing the great *Otozoum* may be a little the newest (Emerson).

Correlation of Distribution in Connecticut Valley and New Jersey Areas

The New Jersey area has produced by no means as many footprint localities as the Connecticut valley, nor have collections been made from them to anything like the extent of the latter. Among the more notable places where footprints have been found, however, are the following:

Avondale. — In the Annual Report of the State Geologist of New Jersey for 1897, p. 155, mention is made of "mud-cracks, ripple-marks, imprints of reptile tracks and bits of coal [being] not infrequently found" in the quarries of the Belleville Sandstone Company. This quarry is in the Brunswick series below the extrusive trap, but I find no record of species represented.

Upon the New Jersey side of the Delaware river a "few miles below Easton, Pa.," Professor C. H. Hitchcock found *Grallator gracilis* and one or two small species in 1867, and the year before in nearly the same locality the large quadrupedal type he has described as *Otozoum parvum* (*? Chirotherium parvum*) (*vide infra* p. 227).

At Milford, a locality which may be identical with the above, at Smith Clark's quarry has been found one of the most complete New Jersey lists, including 6 genera and 8 species of vertebrates and at least 2 invertebrate genera and species. The vertebrate list is as follows:

Anchisauripus parallelus
Argoides macrodactylus
Grallator cuneatus, gracilis
? *Chirotherium* (*Otozoum*) *parvum* (type of the species)
Polemarchus polemarchius
Sauropus barrattii, ingens

This quarry is near the summit of the Brunswick series, lying as it does near the northwestern limit of the Triassic trough, the dip in New Jersey being toward the west, the reverse of that of the Connecticut valley. Of the vertebrate species described, two, ? *Chirotherium* (*Otozoum*) *parvum* and *Sauropus ingens,* are confined to this locality, while the others are all represented in the Connecticut valley area in some of the newest localities of the series, Horse Race, Lily Pond, Turners Falls, Chicopee Falls, Chicopee, and Wethersfield.

At Tumble station about eight miles farther south, also near the Delaware, is an "old quarry from which fine specimens of footprints were once obtained" (Ann. Rept. State Geol. N. J., 1897, p. 156). I do not know whether any of these are now extant nor what species were included. The locality, while still in the Brunswick series, if one may judge from the sketch map published in the Annual Report of the State Geologist for 1897, lies not far from the outcropping of the Stockton beds to the south.

Another locality of note is at Whitehall, again high in the Brunswick series near the northwestern limit of the Triassic trough. This quarry has produced 6 genera and at least 11 species, all of which are also characteristic of the newer horizons of the Connecticut valley, with the exception of *Anomœpus crassus* C. H. Hitchcock, which is unique. The known list of species includes:

Anchisauripus minusculus, parallelus, sillimani
Anomœpus crassus, intermedius, ?isodactylus
Batrachopus gracilis
Eubrontes divaricatus, giganteus
Grallator cursorius, formosus
Steropoides ingens, impressed upon a splendid slab which with its counterpart is preserved at Rutgers College.

Several other localities may be mentioned, such as Pompton Furnace and New Vernon, which bear much the same relationship to the sedimentation as that at Whitehall.

The lowermost recorded track locality is that of the S. B. Twining and Sons' quarries above Stockton, in which "stems of wood and imprints of reptile tracks occasionally occur." The character of these tracks unfortunately seems to be unrecorded. It is my opinion that, were the footmarks in these various localities carefully studied in comparison with the more amply known fauna of the Connecticut valley, they might serve as a valuable criterion for the correlation of the beds in the two areas.

So far as I am able to offer such a comparison now, the facts appear to be as follows:

The Triassic strata in each area are divided by three great lava outpourings which may be assumed to have occurred in each area at approximately the same time. In the New Jersey area, these trap sheets lie relatively much nearer the summit of the series of sediments than they do in the Connecticut valley, which would suggest that the recorded sedimentation may have begun in the former area at a more remote time than in the latter.

The known species of New Jersey footprints occur high in the Brunswick series, and, except for a very few exclusively New Jersey types, have their exact representatives in the upper portion of the Connecticut valley sediments; in each case above the uppermost trap. Relatively few of the great host of valley ichnites are represented in New Jersey, but that may be due to one or more of several causes, and sufficient numbers do occur in common to be conclusive. It is unfortunate that no species are known in New Jersey which may be correlated with those from the Connecticut anterior and posterior shales.

The locality at Belleville near Newark which has produced the reptilian jaw fragment preserved at Yale (*vide supra* p. 79) may be correlated approximately with that of Simsbury, Connecticut, both localities lying below the trap and each producing remains of the crocodile-like phytosaur, *Rutiodon*. Whether or not the species are identical cannot be proven, for in the one case the upper jaw is preserved and in the other a portion of a scapula, between which a comparison cannot be made. No remains of *Rutiodon* are known, however, from the higher levels in either area. Whether the Stockton footprints are analogous to any of the known Connecticut valley forms I cannot as yet say but I very much doubt it. The evidence is very unsatisfactory, due to the dearth of our knowledge concerning the older portion of the faunas, but it may prove that the equivalents of the Stockton and Lockatong are entirely wanting in the Connecticut area, especially as the Simsbury locality is well down in the lower series of coarse granitic sandstones in the Connecticut column while Belleville is still within the limits of the Brunswick shales.

TECHNICAL DESCRIPTION

THE SKELETONS

The Triassic skeletons of the Connecticut valley and adjacent region are all reptilian, representing but two orders and but a meagre proportion of the entire fauna. A résumé of the known forms is as follows:

Class **REPTILIA**

Order **PARASUCHIA** Huxley

Suborder **AËTOSAURIA** Nicholson and Lydekker

Pseudosuchia Zittel

Family AËTOSAURIDÆ Fraas

Stegomus arcuatus Marsh

Stegomus longipes Emerson and Loomis

Suborder **PHYTOSAURIA** Baur

Family PHYTOSAURIDÆ McGregor

Rutiodon (Belodon) validus (Marsh)

Rutiodon manhattanensis v. Huene

Order **DINOSAURIA** Owen

Suborder **THEROPODA** Marsh

Superfamily *MEGALOSAURIA* Baur

Family ANCHISAURIDÆ Marsh

Anchisaurus (Megadactylus) polyzelus (E. Hitchcock, Jr.)

Anchisaurus colurus Marsh

Anchisaurus solus Marsh

Ammosaurus major Marsh

Superfamily *COMPSOGNATHA* Huxley

Family PODOKESAURIDÆ

Podokesaurus holyokensis Talbot

Of these all but four, *Stegomus longipes, Anchisaurus polyzelus, Podokesaurus holyokensis,* and *Rutiodon manhattanensis,* were found within the political boundaries of the state of Connecticut. Of the four exceptions, the first three came from the commonwealth of Massachusetts, the farthest north but fifteen miles from the border, while the fourth was found in the Palisades of the Hudson river near Fort Lee, New Jersey, so that present Connecticut would be well within the range of each species.

Order PARASUCHIA

"Lacertiform reptiles; . . . . body more or less completely encased in bony armor, the plates of which are in part

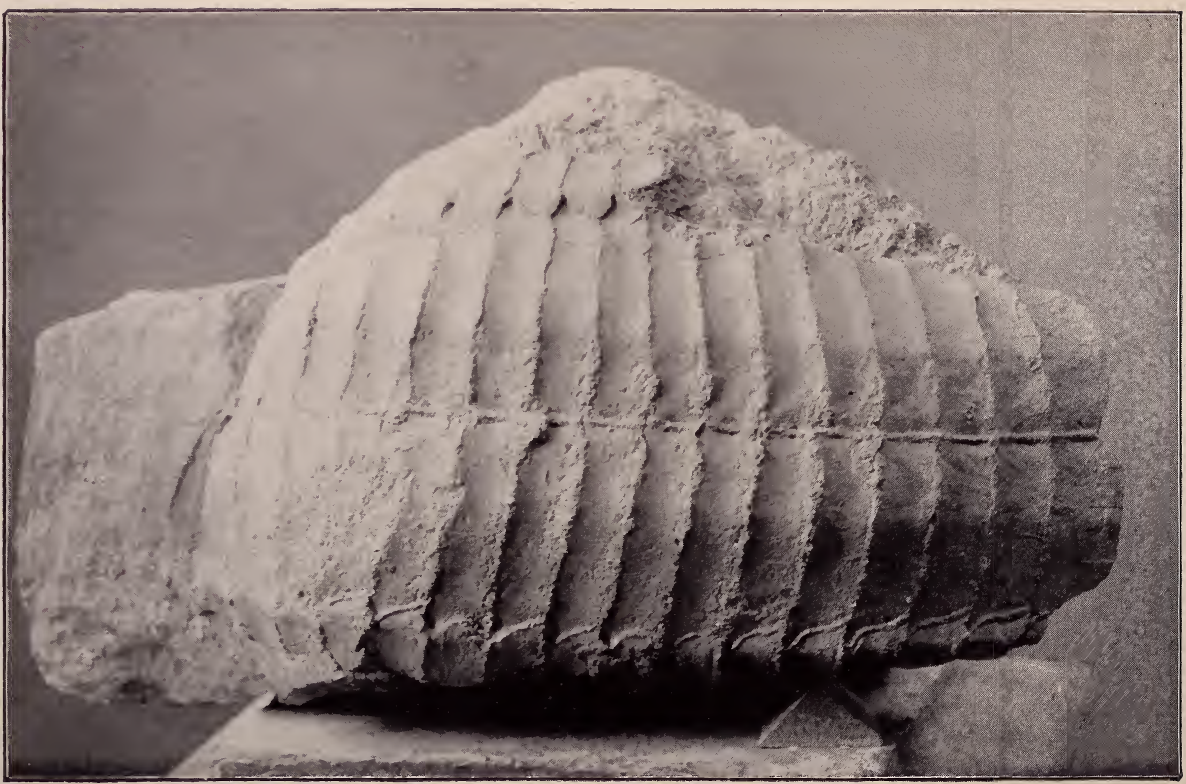

PLATE VII.—Dorsal armor of *Stegomus arcuatus*. One-third nat. size. After Marsh.

metamerically arranged; dentition thecodont; external nares separate; internal nares normal (*i. e.*, no secondary palate); vertebræ amphicœlous, cervicals not exceeding 8-9, sacrals 2. Shoulder girdle complete, well developed interclavicle; all pelvic bones participating in formation of acetabulum" (McGregor 1906, p. 91).

Suborder **AËTOSAURIA**

Family AËTOSAURIDÆ

Stegomus arcuatus Marsh

Marsh, O. C. 1896, Amer. Jour. Sci., (4) ii, pp. 59-62, pl. i.

Type specimen, Cat. No. 1647, Yale Museum.

Locality. — Quarry of Freeman Clark near the State street bridge over the Quinnipiac river in Fair Haven, within the municipality of New Haven, Connecticut.

Horizon. — West of the anterior trap sheet within the limits of the lower series of coarse, granitic sandstone.

Original description. — "The fossil shows the impression of the dermal armor of a large reptile, which apparently represents a new genus of the *Belodontia.* The dermal covering thus preserved is mainly from the dorsal region, although the anterior part protected the back of the neck. No other portions of the dermal armor nor any of the skeleton were found, although a careful search was made at the time of the discovery and subsequently, both at the locality itself and in the vicinity. It is therefore probable that the dermal covering here described was torn from the animal after death and before entombment in the coarse sand and gravel then deposited by a strong current, as indicated by the present structure of the sandstone.

"In the fossil represented in the accompanying plate [Plate vii], the dorsal region of the reptile is shown, with the anterior portion to the left. The median dorsal line is indicated by the narrow longitudinal ridge, placed nearly horizontal in the figure. In the cervical region, this nearly straight line is broken, as the armor was here turned slightly to the right and somewhat twisted. This median ridge was formed by the matrix filling the narrow space between the ends of the dorsal plates, where they met in pairs on the median line. The transverse ridges are likewise due to the filling in of the matrix between the adjoining plates, which evidently were somewhat separated by connecting tissue admitting of more or less motion, but which held the whole dorsal armor together as a carapace.

"The large median plates indicated in this fossil are twenty in number in each of the two rows meeting on the middle line. These plates are elongated transversely, strongly convex, and their form is accurately shown in the figure. Their inner extremities are nearly at right angles to the sides, but the outer ends are oblique where they join the plates of the lateral series, or second row. These lateral plates were quite short, and their form and position are clearly preserved in the specimen figured. All the dermal armor indicated resembles, in its general features, the corresponding portions in the genus *Aëtosaurus* Fraas, from the upper Trias of Germany. In the latter, however, the plates are imbricate [*vide infra*].

"The above description is based upon the impressions left by the inferior side of the plates upon the plastic matrix in which they were imbedded. The plates themselves have since disappeared, having been dissolved by infiltrating waters. The cast of the superior surface of the plates was of somewhat softer material than the matrix below, and most of it was lost in removing the specimen. The portions recovered show that the upper surface of the plates was rugose, but not deeply sculptured, being less marked in this respect than in the other known species of Belodonts. The rough surface preserved shows no regular pattern of ornamentation, and there are no indications of a crest on the plates. The form and position of the plates are characteristic features, and as both the genus and species appear to be distinct, the reptile may be known as *Stegomus arcuatus*. The animal when alive was of moderate size, probably eight or ten feet long. This would be about two-thirds the size of *Belodon validus* [*vide infra* p. 112], the scapula of which is eight and one-half inches in length. The fossil here described indicates an animal with a body capable of some lateral flexure and considerable vertical movement. The type specimen was found by F. P. Clark, and presented by D. A. Van Hise to the Yale University museum."

Additional Description. — The rock is a coarse-grained arkose sandstone, reddish brown in color, and showing no bedding planes. This rock, though coarse, is nevertheless a high-grade building stone. It seems, therefore, to have come within the hardening influence of the trap, though showing no trace of thermal metamorphism.

There is no bone remaining, though bone seems to have been present until after the hardening of the sediments, as the spaces occupied by the dermal bones of the carapace would still be present were the portion of matrix which overlay the specimen yet in place. Enough of the upper rock still remains to indicate this when the detached fragments are returned to their proper place.

I cannot agree with Marsh that the plates show no indication of imbrication, as this is clearly shown by the overlying matrix giving as it does the character of the external surface of the carapace. The anterior margin of some of the plates was depressed as much as 5 mm. below the posterior margin of the one in front. The average depression is about 4 mm. Emerson and Loomis (1904, p. 378) state that in *S. longipes* "the rear margin of each scute overlapped the front of the succeeding one, as is clear in the cast of the upper surface. Marsh considered that in his specimen this was not the case, but the fossil shows only the under surface of the scutes and they appear exactly as do those in the specimen under description. Marsh used this character to distinguish Stegomus from Aëtosaurus, but the contrasts must be found in other characters, as is shown later." These authors overlooked the fact that fragments bearing the impression of the dorsal surface of the carapace of *Stegomus arcuatus* were preserved, though Marsh specifically mentions them. The latter, however, overlooked the perfectly obvious imbrication which the overlying matrix indicates and which is relatively the same as that of the lesser specimen described by Emerson and Loomis.

As in the case of the latter specimen, the upper matrix is coarser in texture than the lower, so that while the character of the lower surface of the scutes is faithfully preserved that of the upper surface is apparently obscured by the coarse granulation of

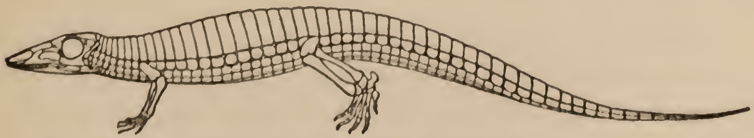

FIG. 9.—Restoration of *Aëtosaurus ferratus* Fraas. One-eighth nat. size. After Marsh.

the material taking the impression. This difficulty, however, is more apparent than real, for a plaster cast in which varying color and size of the sand grains is eliminated gives a true idea of the surface of the bone itself, which is covered by tiny punctuations in series approximately parallel to the anterior and posterior margins of the plate, that is, perpendicular to the long axis of the animal's body. A square centimeter covers about seventy such punctuations arranged in eight rows, which gives an idea of their minuteness upon so large an animal. In *Aëtosaurus* the scutes bear radially arranged ridges upon their upper surface, the center of radiation being eccentrically placed. This would in itself constitute the greatest point of distinction between *Stegomus* and *Aëtosaurus* were the New Haven specimen of the former genus alone known.

Available dimensions of *Stegomus arcuatus* are as follows:

Length of entire carapace as preserved	
Measured over curve	440 mm.
Measured between perpendiculars	410 mm.
Average greatest fore and aft dimension of plates (median row)	25 mm.
Average least diameter	20 mm.
Transverse diameter of largest (10th) plate	94 mm.
Transverse diameter of least (4th and 18th) plates	75 mm.
Average transverse diameter of lateral plates	40 mm.

Stegomus longipes Emerson and Loomis

Emerson, B. K., and Loomis, F. B. 1904, Amer. Jour. Sci., (4) xvii, pp. 377-380, pl. xxii.

Lull, R. S. 1904, Pop. Sci. Monthly, p. 148, text fig. p. 147.

Type specimen deposited in the museum of Amherst College.

Locality. — Hine's quarry, about a mile east of the village of Longmeadow, Massachusetts.

Horizon. — Longmeadow sandstone, in the " upper series of sandstones and shales with local conglomerates " of the Connecticut valley.

Original Description. — " The specimen consists of three pieces containing the major part of the whole animal. All but a thin interrupted film of bone has been leached out, leaving spaces which are filled with calcite. It is, then, largely a cast, both the

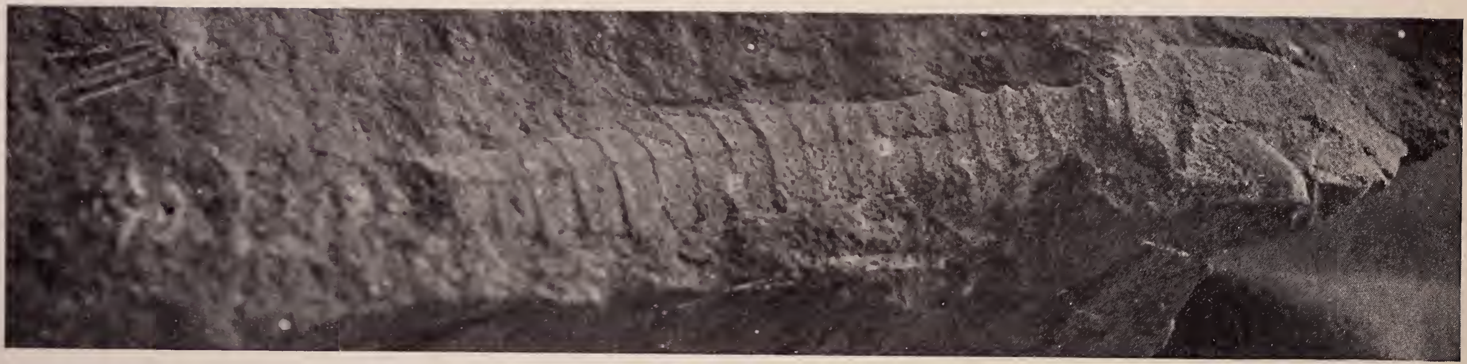

PLATE VIII.—*Stegomus longipes.* After Emerson and Loomis. Nat. size.

upper and lower surfaces of the bone being impressed on one block or the other. The first block contains most of the fossil, the splitting having exposed the under surface of the bones roofing the head, of the carapace from the head to the pelvis (28 pairs of plates), the bones of the right arm and left foot. The second block contains the impression of the upper surface of the same parts. The third is a chip, flaked off just in front of the pelvis and exposing the vertebræ of that region.

"*Skull.* — This is broadly triangular in outline, tapering to a pointed snout. The upper surface of the cranium seems to have been completely roofed with bone, except possibly directly over the orbit. Two supraorbital bones are distinctly indicated, but between them and the frontals is a space which seems to have been open (see ? in fig. 2, Pl. xxii) [fig. 10 *B*]. Sutures are present showing that the dermal bones were paired along the middle line. The premaxillæ are short, the nasals are rather long, but the boundaries of the other bones cannot be made out. A vertical break shows the side of the skull imperfectly, as restored in fig. 3, Pl. xxii [fig. 10 *A*]. The parts actually present are indicated by the complete line, while restoration is indicated by a broken line. It is a low skull, being about one-third as deep as long. The quadratum is well back, making a long jugal arch. An antorbital vacuity is present though its boundaries are very imperfectly indicated. The orbit is moderately large, being distinctly bounded off from the temporal vacuities as indicated. It has above it at least two supraorbital bones. That there is a large lateral temporal vacuity is certain. A forward projection of bone in the squamosal region seems to indicate a dividing arcade between this and a supra-temporal vacuity, but the arcade is not complete and is not therefore certain. On the maxilla of the left side one tooth and a part of a second is preserved, showing them to be tiny conical affairs. The depth of the lower jaw is about 3 mm., being a light slender mandible.

"*Carapace.* — The dorsal side of the body was protected by a double row of plates, on either side. Those along the middle line are wide, their outer edges being flanked with small quadrate scutes. From the head to the pelvis there are 28 sets of plates, which are narrow and inflexed in the neck region, widen till the middle of the body is reached, and then gradually taper toward

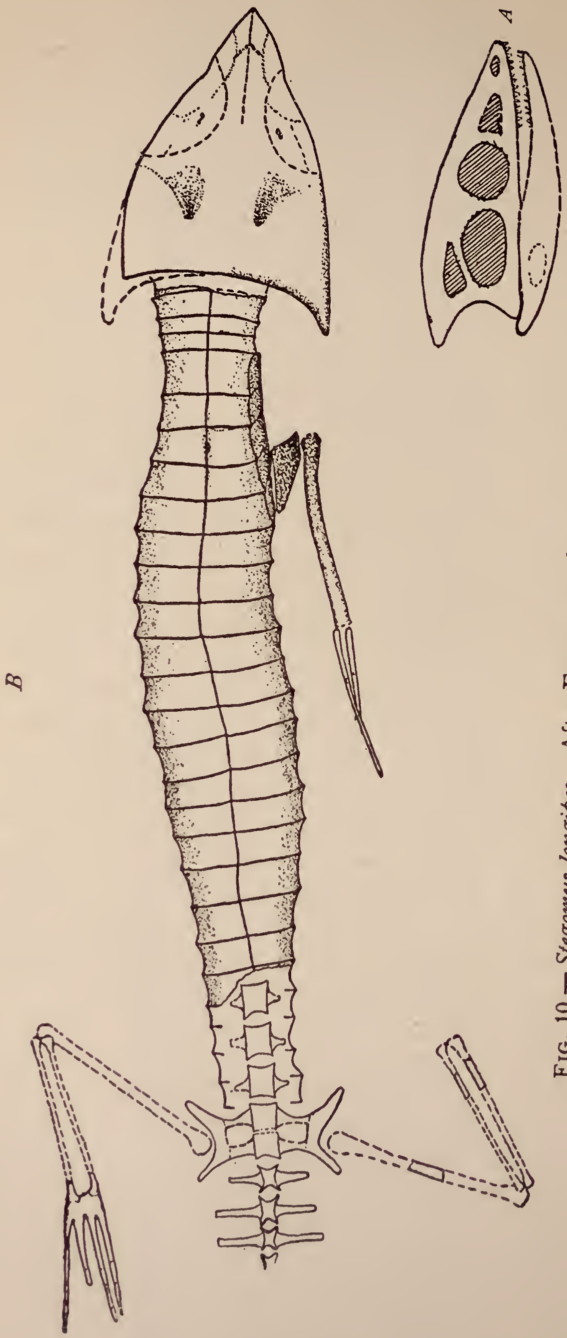

FIG. 10.—*Stegomus longipes*. After Emerson and Loomis. *A*, side view of skull; *B*, dorsal view of head and body.

the tail. The arrangement and relations of these scutes are seen in fig. 2 [fig. 10 *B*]. Each plate of the median row is usually about 4-4½ mm., from front to back. The third and fourth, however, are about half as wide as the rest, while the fifth is much the widest, being wider than the two preceding taken together. Possibly some of this variation is due to the curvature of the neck, but most of it is clearly the bone itself. The rear margin of each scute overlapped the front of the succeeding one, as is clear in the cast of the upper surface. . . . . Along the outer margins of plates 5-9 small quadrate scutes were brought into sight by preparation. The nature of the fossil does not permit further preparation, but doubtless similar scutes occur all along the side of the body. On the cast of the upper surface of the scutes, there are indications that the surface was pitted, but the coarseness of the sandstone prevents certainty.

"*Vertebræ.* — Three presacrals are exposed, each deeply biconcave and with long transverse processes. Two vertebræ only are involved in the sacrum, their moderately long transverse processes supporting the ilium. How completely they are united is not clear on account of the broken condition of the vertebræ, but they appear slightly separated. Three and a half deeply biconcave caudals are all that are preserved. The transverse processes of these are even longer than on the presacrals and quadrate in section. From the sacrum back they are progressively longer, suggesting a broad flat tail such as is known for Aëtosaurus.

"*Fore Limb.* — Of the pectoral girdle only the scapula is present, and this is a broad triangular bone 9 mm. long by 5 mm. deep. Its upper margin lies parallel to small lateral plates 7-9 in the series. The leg is unusually long, the slender humerus being 1½ mm. in diameter and 24 mm. in length, a bone nearly straight and swelling slightly at either end. The radius and ulna are but ¾ mm. in diameter and 19 mm. long. As the specimen lies, the radius crosses the ulna, but whether this indicates great flexibility or is mere chance is not to be determined. The fore foot is lacking.

"*Hind Limb.* — An ilium 12 mm. long, the front and rear ends of which curve strongly outward, is present, but only its rough outline is to be made out. Of the limb bones only short fragments are discernible, where they are broken across; but enough is visible to show the direction and diameter of the bones, and by extending these the length can be approximately found. This indicates a leg slightly longer than the fore leg. The femur was 1½ mm. in diameter and 26 mm. in length (by reconstruction). The tibia and fibula are each about the same size, ¾ mm. in diameter and 21 mm. long (by reconstruction). The left foot is well preserved. The individual tarsals are not to be made out. Four toes are well preserved, but a fifth is nowhere even indicated. The length of the toes on the figure is probably a little short, as each seems incomplete at the end. The metapodials are long, but the details of the toes do not come out with certainty, though a slight widening at intervals was taken to indicate the joints, and they are drawn on that supposition.

" *Comparison.* — This animal resembles most closely Marsh's *Stegomus arcuatus*, of which twenty dorsal sets of plates are described. It is a much smaller species and presents most of the important features, thus allowing a conception of the animal and its relationships. *Stegomus longipes* is about one-third [*vide infra*] the size of the preceding species, which is the only comparison readily made, as Marsh's fossil is so incomplete. It belongs to the Aëtosauridæ[1] and resembles that genus in many important features, but there are enough characters of weight to demand a separate genus, as established by Marsh. Ornithosuchus and Erpetosaurus of Newton[2] also have some features resembling *S. longipes* but are far wider differentiated than the German genus. Aëtosaurus has about twenty-five sets of plates from the head to the pelvis, each consisting of a median pair of large scutes and small quadrate scutes outside these. Stegomus has about twenty-eight exactly similar [*vide infra*] sets of plates.

" In the skull, however, there are marked contrasts. The orbit of both genera is bounded above by extra supraorbital bones, but the orbit of the Aëtosaurus is further back than that of Stegomus; the result of which is that the former has only a single small supra-temporal vacuity, while the latter has at least a very large vacuity, and possibly that divided into a supra-temporal and a lateral temporal vacuity. The Stegomus has a wider skull and above the orbit a vacuity or at least a deep depression. The vertebræ of Aëtosaurus are procœlous, while those of Stegomus are amphicœlous. Ornithosuchus has platycœlous vertebral centra. The sacrum in the other known Aëtosauridæ includes three vertebræ, but in Stegomus only two are united to the ilium. Both the fore and hind limbs of Stegomus are much longer and more slender than the Aëtosaurus, this being the character which has suggested the specific name longipes.

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[1] Frass, O., 1877, Württemb. naturw. Jahreshefte, xxxiii, Festschrift.

[2] Newton, E. T., 1894, Phil. Trans., vol. clxxxv Reptiles of Elgin Sandstones.

"The features above described show this fossil to be the remains of a small armoured lizard-like creature, with long legs. It seems to be a land form and of extreme agility.

"The following are the measurements of the principal parts:

Length from snout to root of tail	149 mm.			
Length of skull	35 mm.			
Breadth of skull in occipital region	27 mm. (29 allowing for fracture)			
Depth of skull in quadrate region	11 mm.			
Median Plate 2	8 mm.	transversely	by 4½	longitudinally
" Plate 3	5½	"	" 2	"
" Plate 4	5	"	" 2½	"
" Plate 5	4½	"	" 5	"

"The succeeding plates gradually increase transversely up to 10 mm. at about the middle of the body and then slowly diminish again. All are drawn to scale in figure 2, Pl. xxii [fig. 10 *B*].

"The vertebral centra in front of the pelvis are 3½ mm. long by 3 mm. wide. Caudal vertebræ 3 mm. long by 2 mm. wide. The transverse process of the last vertebræ are 6 mm. long."

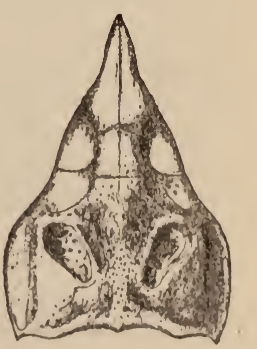

FIG. 11.—Skull of *Stegomus longipes*. Nat. size. Original.

Additional Description. — The original specimen has not been available for my study, but from a squeeze taken some years ago the figure of the skull here shown (fig. 11) has been made. It differs in some details from that published by Emerson and Loomis, probably for the reason that their figure was drawn from the first block, showing the impression of the under side of the cranial bones, while mine was from the second block, which contains the impression of the upper surface, and hence the squeeze gave an actual reproduction of the dorsal aspect of the skull itself. The supratemporal vacuities are plainly indicated, and I have carried out the apparent lines of the muzzle in such a way as to make it longer and more attenuated, more as in *Aëtosaurus.* The proportions of the skull with the position of the orbit are still however quite different from those of *Aëtosaurus* as the authors indicate.

The punctate character of the surface of the dermal bones of *Stegomus* differs markedly from that of *Aëtosaurus,* in which the scutes are ornamented by radially arranged striæ. Therefore the scutes are not "exactly similar" as Emerson and Loomis have said. Specific distinctions between *Stegomus arcuatus* and *S. longipes* are, first, that of size, the *S. arcuatus* being about six times larger than *longipes,* not thrice as the authors state. Another distinctive feature is in the character of the outer margin of the median row of dermal plates in *S. arcuatus,* which is oblique, forming a decided angle with the front and rear margins. On the other hand in *longipes* these outer margins are very nearly parallel to the median line of the animal with only a slight tendency to diverge at the rear edge of each plate. As I have shown, the supposition that in *arcuatus* the dorsal scutes are non-imbricate is erroneous; the two species being similar in this respect as well as in the finely punctate character of the outer surface of the bone.

Stegomus arcuatus comes from the lower series of sandstones of the Connecticut valley, following which are the anterior trap, anterior shales, main trap sheet, posterior shales, posterior trap and a very considerable deposition of the upper series of sandstones and shales, before the horizon of the Longmeadow sandstone containing *S. longipes* is reached, implying a great lapse of time, as more than 2,000, perhaps more than 3,000, feet separate the nearest limits of the sandstones which bear them.

Aëtosaurus seems to have been a terrestrial reptile. The marvelous group of twenty-four skeletons which is preserved in the museum at Stuttgart apparently implies that the animals were killed by the caving in of the sandy roof of the shelter in which they had taken refuge. One at least is pathetic in its appealing efforts to escape as indicated by its posture. *Stegomus* again seems to have been terrestrial, at least *S. longipes* does; of *arcuatus* one cannot be quite so sure, as the remains are too meagre to speak of their owner's adaptations and the body was embedded in stream-borne sediment. *Longipes* on the other hand seems to show a distinct cursorial adaptation; and I have correlated the animal with the footprint species *Batrachopus gracilis* (Lull 1904 C, p. 381) (*vide infra* p. 177), in which the quadrupedal gait, long stride, and narrow trackway imply a mammal-like mode of progression while the tracks of hand and foot are distinctly reptilian.

The size, proportions, long slender limbs with straight-shafted bones unlike those of a modern sprawling reptile, — all are arguments in favor of the cursorial gait shown in the restoration, Plate ii, page 39 (see Lull 1904 B, p. 147, fig.). Emerson and Loomis refer to the crossing of the ulna by the radius but cannot determine whether this indicates great flexibility or is mere chance. It seems rather to be in line with the present argument, for the ulna, being articulated with the inner condyle of the humerus and the external side of the wrist, will naturally be crossed by the radius when the elbows are drawn in against the animal's side and the digits directed forward palm down — in other words, in the mammalian attitude of the limb which was also that assumed by the quadrupedal dinosaurs (see *Stegosaurus* — Lull 1910, Amer. Jour. Sci., (4) xxx, fig. 3, p. 364).

The nearest old-world relative of *Stegomus* is *Aëtosaurus* and they may well represent derivatives from a common stock. The modification which *Stegomus* has undergone may well be, as in the case of the dinosaurs, an adaptation to arid climatic conditions, when good cursorial powers were, from the relative scarcity of food and water, of great selection value. *Stegomus* may have followed the same route of immigration from the Old World as the dinosaurs did, though in the absence of knowledge concerning footprints from the level of *S. arcuatus* one cannot say positively whether the dinosaurian horde followed the aëtosaur or accompanied it. The former, however, is my belief.

Suborder PHYTOSAURIA

Rutiodon validus (Marsh)

Marsh, O. C. 1893, Amer. Jour. Sci., (3) xlv, p. 170. (*Belodon*).

Marsh, O. C. 1896, Amer. Jour. Sci., (3) ii, p. 59.

McGregor, J. H. 1906, Mem. Amer. Mus. Nat. Hist., ix, pt. ii, p. 95 *(Rhytidodon carolinensis)*.

Type specimen, Cat. No. 2138, Yale Museum.

Locality. — Simsbury, Conn., in the quarry of Orestes Wilcox, half a mile southwest from the station; found in 1888.

Horizon. — Below the anterior trap sheet; approximately the same level as that of *Stegomus arcuatus* (*vide supra* p. 99).

Original description. — "The only other reptile known from the Connecticut sandstone by any part of the skeleton is a large *Belodon* from a lower horizon. This crocodilian may be called *Belodon validus,* and will be described by the writer later."

The only further reference to this species by Marsh is in the description of *Stegomus arcuatus* (Marsh 1896 A, p. 59) in which he says:

"The *Belodontia,* one of the most characteristic groups of Triassic reptiles, are almost unknown in the Connecticut river sandstone, a single specimen only having been discovered, and recently named by the writer *Belodon validus*." Below (*op. cit.* p. 60) Marsh again says in speaking of the size of *S. arcuatus,* "The animal when alive was of moderate size, probably eight or ten feet long. This would be about two-thirds the size of *Belodon validus,* the scapula of which is eight and one-half inches in length." Marsh's promise of further description was thwarted by destiny.

McGregor (1906, p. 95) includes under the species *Rhytidodon* (*Rutiodon*) *carolinensis* no fewer than fifteen names which he believes "all synonyms, with the possible exception of *Belodon validus*, from the Trias of Connecticut, which was named, but not described, by Marsh."

Character of the specimen. — The specimen consists of the proximal portion of the right scapula only, with the outer aspect still embedded in the rock so that some of the details are obscured. Compared with the figure of the left scapula of *Rutiodon carolinensis,* published by McGregor (*op. cit.,* pl. ix, fig. 20), the bone under discussion seems to be about half again as large in most of its dimensions except the vertical length of the glenoid fossa. The description of the bone in *R. carolinensis,* p. 70, tallies with that of *validus* in so far as the details of the latter specimen are preserved, except that *validus* seems to be relatively more robust. The union with the coracoid is, as McGregor says, a synarthrosis, permitting little or no motion, and in the synarthrosis the scapular surface is concave. This concavity does not seem to tally exactly with that of *carolinensis* if one may judge from the figure of the complementary surface of the coracoid, for a ridge on the latter, indicating a corresponding groove on the proximal end of the scapula, runs obliquely forward and inward in *carolinensis* while in *validus* it is almost transverse

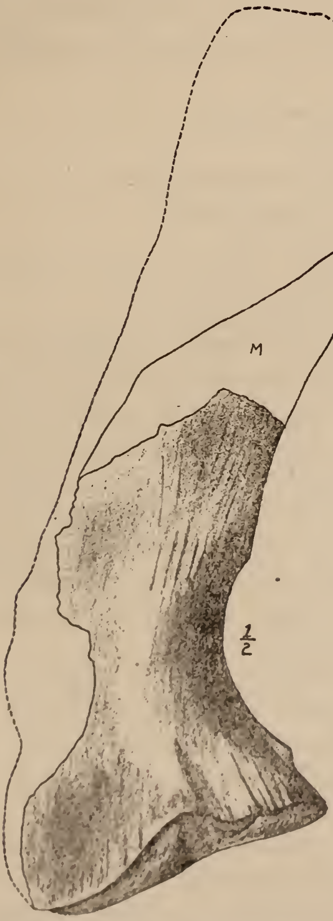

Fig. 12.—Scapula of *Rutiodon validus*. One-half nat. size. Cat. No. 2138, Yale Museum.

though inclining slightly backward instead of forward. Above the glenoid face in *carolinensis* very distinct roughenings are indicated on the posterior aspect of the scapula, in *validus* the same area is smooth in so far as it is possible to observe it. There is also in the figure of *carolinensis* a very distinct fissure defining the forward limitation of the glenoid fossa, which is lacking in *validus*.

The principal features therefore in *Rutiodon validus*, in contrast to *carolinensis*, are its greater robustness, absence of the roughening above the glenoid fossa, absence of the posterior defining fissure, and the position of the transverse groove on the coracoid facet. On these distinctions the validity of *validus* must rest.

The principal measurements are:

Estimated length (Marsh's)	215 mm.
Antero-posterior diameter of coracoid facet	64 mm.
Transverse diameter of coracoid facet	35 mm.
Greatest diameter of proximal end	56 mm.

McGregor (p. 92) thus characterizes the Phytosauria, to which group *Rutiodon validus* belongs:

" Large diapsid reptiles, strongly resembling the Crocodilia in external form and in habit, but differing in the fact that the elongate snout is prenarial (formed almost entirely by the premaxillary bones), the nares separate, and located near the eyes, internal nares directly below external; no secondary palate. Teeth of carnivorous type, conical or with trenchant edges. . . . . Dermal armature on neck, trunk, and tail, consists of sculptured bony plates, arranged metamerically on the dorsal surface, usually in four series. Ventral surface naked (?) or partly protected by a throat-shield of small scutes.

" The Phytosauria were more or less aquatic, inhabiting the fresh-water lakes and rivers of the Triassic period. Their remains are known in the Trias of Germany, England, and Scotland, eastern and western North America, India, and probably South Africa."

Rutiodon was further characterized by a long, attenuated, gavial-like snout and slender conical teeth. Modern gavials of doubtless similar feeding habits are found in the large Indian rivers, and in the Malay peninsula, Sumatra and Borneo, and feed almost exclusively on fish.

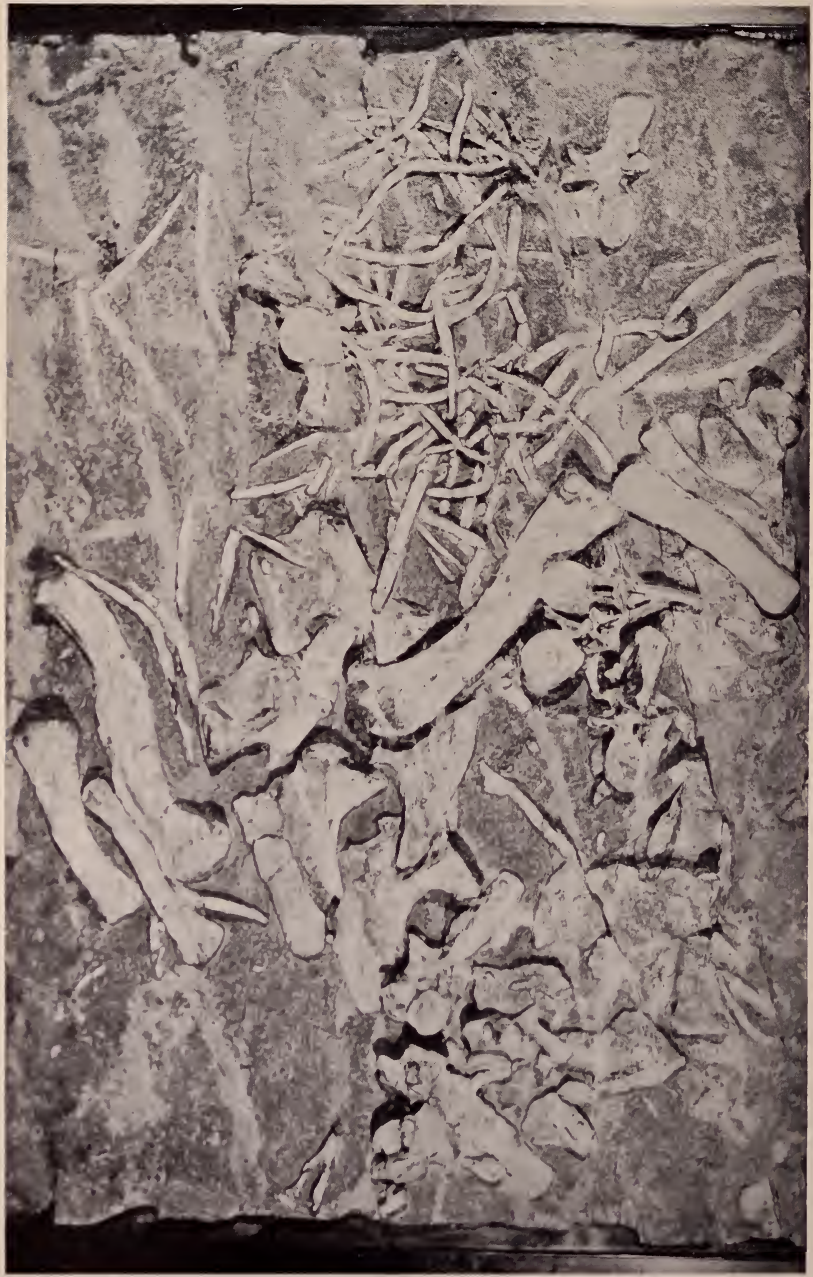

PLATE IX.—*Rutiodon manhattanensis* v. Huene. Skeleton as preserved in the original matrix. About one-tenth nat. size. After v. Huene.

The presence of *Rutiodon validus* at Simsbury implies the existence during early Newark time of a large river or fresh-water lake containing sufficient fish for the maintenance of animals some of which were about twelve feet in length.

Rutiodon manhattanensis v. Huene

Huene, F. v. 1913. Bull. Amer. Mus. Nat. Hist., xxxii, Art. xv, pp. 275-282, pl. xlix, text fig. 14.

Type specimen, Cat. No. 4991, American Museum of Natural History.

Locality. — Fort Lee, New Jersey, on the right bank of the Hudson river, opposite New York City.

Horizon. — Twenty feet below the thick sheet of basalt of the Palisades in a red sandy marl hardened by the overlying trap; hence near the base of the Newark series.

Original description. — "The large plate of matrix (155×125 cm.) contains the pelvis, both hind legs without feet, small parts of the body and tail and a few dermal scutes (Pl. 1) [Pl.ix].

"*Dorsal vertebræ:* There are 4 vertebræ belonging to the thoracic region as they possess relatively long diapophyses. The dorsal spines are but little lower than in *Rutiodon Carolinensis* (*cf.* MacGregor: Mem. Am. Mus. Nat. Hist., ix, 2, 1906).

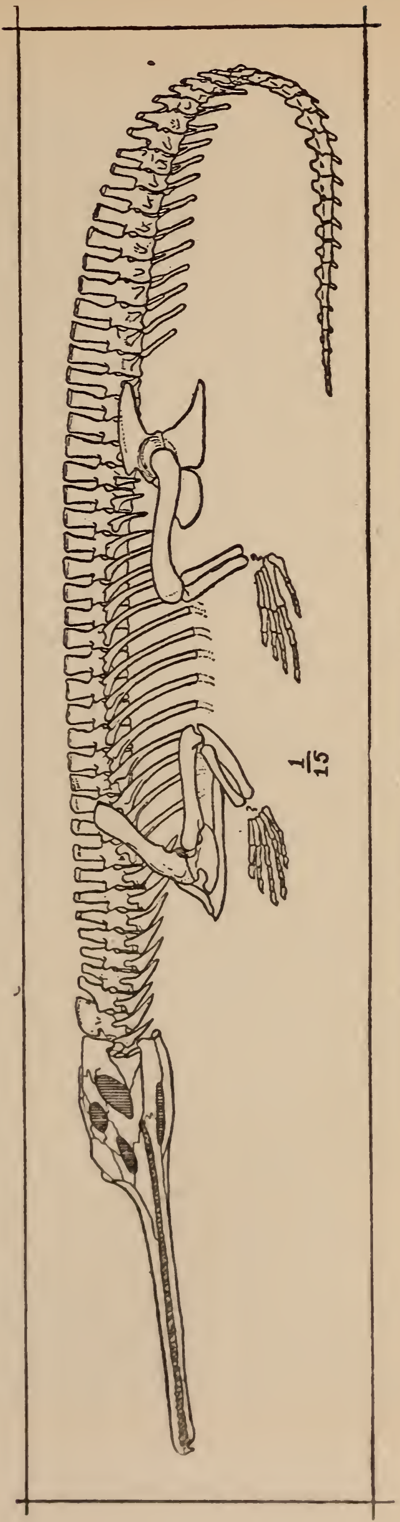

Fig. 13.—*Rutiodon carolinensis.* One-fifteenth nat. size. After McGregor.

"*Sacral vertebra*: A sacral vertebra without upper arch is lying near the abdominal ribs. It seems to be the first sacral vertebra, because the sacral ribs are much weaker than those of the second sacral vertebra of *R. carolinensis* shown by MacGregor.

"*Caudal vertebræ*: 4 anterior caudal vertebræ and fragments are lying near to each other behind the pelvis. They possess very high and straight dorsal spines similar to those of *R. carolinensis*.

"*Hæmapophyses:* Remains of two hæmapophyses are visible; both of them lack the lower end. One of them is still attached to the penultimate tail vertebra by its articular facets, but most of the other parts are missing. The second specimen shows the articular facets divided as in all Parasuchians, which in contradistinction to those of dinosaurs are not connected by a bridge.

"*Ribs:* Beside the left tibia and fibula there are few thoracic ribs, but no articular ends are preserved. Also the rib lying over the left pubis is a thoracic rib.

"*Abdominal ribs*: A large number of abdominal ribs are lying anterior to the pelvis. They are straight and slightly curved; several of them (6) are apparently of the median line and show a sudden curvature in lesser (for instance two on the side of the right femur) or greater (4 or 5 in the big mass) degree. They belong to the median and posterior part of the plastron. Two specimens below the sacral vertebra form a sharp angle and consist of two straight branches; they come from the most anterior part of the plastron.

"*Ilium*: Both ilia show their lateral aspect. The left ilium is partly covered by the proximal end of the left femur. The contour of the ilium is — except for the closed acetabulum — more similar to that of the Triassic Theropoda than to that of the European Phytosaurs, because it is lower and longer and at the same time possesses a sharp spine directed anteriorly. The ilium if compared with *R. carolinensis* shows the following distinctions: in *R. carolinensis* the contact line of the pubis at the lower border is relatively much shorter than in the recently discovered specimen. The length of this contact line in *R. carolinensis* is one third of the distance from the spina anterior to the spina posterior, but in this specimen only a little more than one half. The whole breadth of the acetabulum is nearly the same: the distance from the spina anterior to the spina posterior is one third longer than the width of the acetabulum in this specimen and one half in *R. carolinensis*. There is not much difference in the vertical breadth in the two species. The upper border in *R. carolinensis* is a little more curved and the posterior process a little narrower than in this species.

"*Pubis*: The left pubis is lying near the caput of the left femur, and the posterior process of the right ilium is above it. The bone shows the ventral face. The right pubis is near the lower border of the plate. The pubis of *R. carolinensis* is a good deal shorter as compared with the ilium, and compared with its own length it is broader than in the new species.

"*Ischium*: The left ischium is but little displaced near the left ilium and covers a small part of the right ischium; the latter shows the medial and this the lateral face. The whole bone is heavier and the posterior end broader than in *R. carolinensis*.

"*Femur*: The left hind leg lies near the abdominal ribs and the dorsal vertebræ, the right leg near the isolated pubis. The femur in its form (as the ilium) is similar to that of the Triassic Theropoda, only it is more curved. Its length is 43-44 cm. and it is the largest Parasuchian femur I have ever seen (*Mystriosuchus rütimeyeri* has a length of 40 cm.).

"*Tibia and Fibula*: The tibia is extraordinarily heavy as compared with all other Parasuchians. It is the same with the fibula which shows an S-like curvature. In the right leg the distal end of the fibula is lying near the proximal end of the tibia. The femur is but little more than 1½ times the length of the tibia (1.57 : 1.00). In *R. carolinensis* this relation is quite different (1.97 : 1.00).

"*Dermal scutes*: The dermal scutes are not very well preserved, but one can recognize the same type as in *R. carolinensis* and the European *Mystriosuchus* which is quite different from *Phytosaurus*. In particular one scute of the tail is in fairly good preservation and shows the characteristic form.

"From this last similarity it is justifiable to conclude that the skull had a long and low snout. . . .

"The comparison of the two specimens [that of Fort Lee and *R. carolinensis*] shows at least a specific difference. Therefore I propose to call the New York animal *Rutiodon manhattanensis* n. sp. The species described by Marsh as *Belodon validus* is based only on a fragment of a right scapula (Yale University collection No. 2056 [2138]). It is not adequate for the type of a species. . . .

"The skull of *Rutiodon* has already been compared with European Phytosaurs, but not so the skeleton to any extent. *Rutiodon* and the European *Mystriosuchus* are hardly different, generically, and should probably be united in one genus, as I have already proposed some time ago, only the name *Rutiodon* dates from 1856 and is very much older than *Mystriosuchus*. Prof. E. Fraas very kindly gave me the opportunity of seeing all the remains of *Mystriosuchus* and *Phytosaurus* in the Stuttgart Museum. The skeletal difference between these two genera is very clear. The centra of cervical and dorsal vertebræ are shorter in *Phytosaurus* and the dorsal spines everywhere lower, especially in the anterior dorsal and anterior or entire caudal region. The whole construction of the vertebræ is higher in *Mystriosuchus* (the same in *Rutiodon*). The thickening of the upper end of the dorsal spines of the cervical, anterior dorsal, and anterior caudal vertebræ is greater in *Phytosaurus* than in *Mystriosuchus*, and the latter does not have any thickening at all of that part in the caudal vertebræ. In the anterior girdle the interclavicle has a different form in the two genera. In the posterior girdle most of the differences are in the ilium. The main difference in the femur is a strong curvature at the beginning of the distal third of its length in *Phytosaurus;* it is more curved than in any *Mystriosuchus* or *Rutiodon*. The difference in the dermal armature is sufficiently known.

"I should think *Rutiodon* and *Mystriosuchus* were better swimmers than *Phytosaurus* on account of their higher vertebræ (giving space for stronger musculature) and more compressed body. The slender-snouted Phytosaurs are the largest ones; *Mystriosuchus rütimeyeri* is the latest and at the same time the largest European form; but *Rutiodon manhattanensis* is the largest one I have ever seen."

It is quite evident from the foregoing description that the present species cannot be compared with *Rutiodon validus* (Marsh) as the two specimens do not include the same elements. Future discovery may prove their identity, in which event Professor Marsh's name must take precedence, for, although the type material is meager, the species seems to be sufficiently characterized to be valid.

Order **DINOSAURIA**

This order of reptiles includes two main divisions, Saurischia and Ornithischia; embracing in the first the suborder of carnivores, the Theropoda, and their derivatives, the huge, probably herbivorous Sauropoda; and in the second the predentate herbivores, which include the unarmored Orthopoda, the armored Stegosauria, and the horned Ceratopsia. Von Huene has lately advanced the idea that the dinosaurs may be diphyletic and that no relationship should be implied between the Saurischia on the one hand and the Ornithischia on the other (Von Huene 1908, Anat. Anzeiger, Bd. xxxiii, pp. 401-405). However this may be, but two groups are represented in the Newark fauna, both among the most primitive representatives of the order; on the one hand the carnivorous Theropoda represented by skeletons and a great abundance and variety of footprints, and on the other the herbivorous unarmored Orthopoda whose presence is thus far betrayed by the footprints only and these of no very great variety (*vide infra* p. 207).

The first evidence of the coming of the dinosaurs to North America is apparently in the footprints found in the anterior shales of the Connecticut valley, and these are entirely of Theropoda, as the Orthopoda are apparently not in evidence until after the last volcanic outflow of the posterior trap sheet.

The suborder Theropoda may be thus defined:

" Carnivorous Dinosaurs with small cranium, the long axis of which is approximately at right angles to that of the neck. Margin of the jaws provided with laterally compressed thecodont cutting teeth. Brain-case incompletely ossified; antorbital vacuity large. Mandibular ramus without coronoid process, and usually pierced by a lateral foramen in its hinder half. Vertebral centra hollowed, the cervicals flattened in front and concave behind, post-cervicals amphiplatyan or slightly amphicœlous. Sternum unossified, acetabulum perforate. Pubes slender, projecting simply downwards, and united distally, like the ischia, in a symphysis which is often much extended. Post-pubic process not developed. Limb bones hollow, fore limbs considerably shorter than the hinder pair; digits three to five in number, provided with prehensile claws; hind feet digitigrade. Femur with inner trochanter; astragalus with ascending anterior process" (Zittel-Eastman). Some of these features, however, were not perfected during Triassic time.

Two superfamilies are represented by their osseous remains in the Newark rocks: the Megalosauria, the greater sort, including *Anchisaurus* and *Ammosaurus;* and the Compsognatha, with but one representative, *Podokesaurus.*

Superfamily *MEGALOSAURIA*

Family ANCHISAURIDÆ

Genus **Anchisaurus** Marsh

Marsh, O. C. 1885, Amer. Jour. Sci., (3) xxix, p. 169.

Generic History. — The name *Megadactylus* was given to the type species *polyzelus* by E. Hitchcock, Jr., in 1865 (Appendix [A]) at the suggestion of Sir Richard Owen and in allusion to the large first digit of the hand.

Marsh in 1882 (Amer. Jour. Sci., (3) xxiii, p. 84) substituted the term *Amphisaurus* for that of *Megadactylus* (preoccupied) in a classification of the Dinosauria which he offered. He may be quoted as follows:

"*Amphisauridæ.* Vertebræ biconcave. Pubes rod-like; five digits in manus and three in pes.

"Genera *Amphisaurus* (*Megadactylus*), *? Bathygnathus, ? Clepsysaurus;* and in Europe, *Palæosaurus, Thecodontosaurus.*"

This term *Amphisaurus* is also used by Baur in 1882, p. 443, and in 1884, p. 447.

In 1885 (p. 169) Marsh proposed the name *Anchisaurus* for *Amphisaurus* which in turn proved to be preoccupied. He also stated that the family name should be Anchisauridæ, but no amended definition of the family was offered at this time. As this change was made before the description, though after the discovery, of the second species included under this genus, *Anchisaurus* (later *Ammosaurus*) *major* Marsh, 1889, the generic name *Anchisaurus* could only refer to Hitchcock's *Megadactylus polyzelus* although no such specific reference was made by Marsh. *Anchisaurus* (*Megadactylus*) *polyzelus* (E. Hitchcock, Jr.) thus stands as the type species of this genus.

The last definition of the family Anchisauridæ given by Marsh is that in "Dinosaurs of North America" (1896 B, p. 239):

"Skull light in structure, with recurved, cutting teeth. Vertebræ plane or biconcave. Bones hollow. Ilium expanded behind acetabulum; pubes rod-like and not co-ossified distally; no interpubic bone. Fore limbs well developed; femur longer than tibia; astragalus without ascending process; five digits in manus and in pes.

"Genera *Anchisaurus* (*Megadactylus*), *Ammosaurus, Arctosaurus* (*?*), *Bathygnathus,* and *Clepsysaurus,* in North America; and in Europe, *Palæosaurus, Thecodontosaurus.* All known forms, Triassic."

Later developments would eliminate from this list the non-dinosaurian *Arctosaurus,* also *Bathygnathus* which is a pelycosaur, and *Clepsysaurus,* a phytosaur.

The species may be discussed in their chronological order, with the exception of *Ammosaurus major,* as follows:

Anchisaurus polyzelus (E. Hitchcock Jr.)

E. Hitchcock 1858, Ichnology of New England, pp. 186-187 (without a name).

E. Hitchcock, Jr. 1865, The Ichnology Supplement, p. 39, Appendix [A] (*Megadactylus*).

Cope, E. D. 1870, Trans. Amer. Phil. Soc., xiv, p. 122 A, pl. xiii (*Megadactylus*).

Marsh, O. C. 1892, Amer. Jour. Sci., (3) xliii, pl. xvi, fig. 3, pl. xvii, fig. 6 (*Anchisaurus*).

Marsh, O. C. 1896, Din. of N. A., p. 147, pl. iii, figs. 4, 5 (*Anchisaurus*).

Huene, F. v. 1906, Din. Aussereurop. Trias, pp. 19-22, figs. 10, 10a (*Thecodontosaurus*).

Type specimen preserved in the museum at Amherst, Ich. Cat. No. 41/109-118.

Locality. — Water shops, U. S. armory, Springfield, Mass.

Horizon. — Longmeadow sandstone, from the upper series of sandstones, etc., of the Newark beds.

Original Description. — This animal was originally described, without a name, by E. Hitchcock as follows:

"The Springfield bones were discovered by William Smith, Esq., while engaged in superintending some improvements at the water shops of the United States Armory, which required blasting. He did not discover them till a large part had been taken away by the workmen. General Whitney, superintendent of the armory, very kindly ordered a re-examination of the fragments, and Mr. Smith obligingly presented me with whatever pieces could be found. These I put into the hands of Professor Jeffries Wyman, and just before he started for Surinam in February, 1857, he sent me the following statements in relation to these fossils: —

" 'With regard to the bones, I think that there can be no question that they are those of a reptile. This is shown by the configuration of the head, small trochanter, and a part of the shaft of a thigh bone, as well as by the imperfect caudal vertebræ; these last, however, are deficient in the concavo-convex bodies which are found in all scaly reptiles except the Enaliosaurians. Those from the sandstone are flat, or nearly so, on the ends, as in the Mammalia. The most remarkable feature, however, of the whole collection, is that of *hollowness*. This is carried so far, that but for the indications referred to, they might be referred to birds. Every bone except the vertebræ, and perhaps the small phalanges, is hollow. Nothing of the kind is known in Mammalia. . . . While the bones from Springfield are as hollow as those of the Pterodactyle, I do not find that they are those of this animal; there is no positive proof of the long fingers, or of the broad sternum which these flying reptiles possessed. The remnants of the foot indicate that the toes were of disproportionate sizes, there being one large toe associated with three quite small ones; perhaps another existed, but there are no signs of it. The claw of the large toe was very strongly recurved. The terminal phalanx of the other toes is deficient, so that we are uncertain even as to the number of the joints. The existence of the large toe in company with the small ones is in favor of a jumping animal.' " [Unfortunately, Professor Wyman apparently did not know that he was describing the hand and not the foot. R. S. L.]

In Appendix [A] of the Ichnological Supplement Doctor Edward Hitchcock, Jr., thus writes concerning this animal:

" Since the description of the bones on the 187th page of the Report on Ichnology was made, they have been shown to Professor Owen, of the British Museum, London, and a few new points have been made out, by more thoroughly exposing them with a graver.

"Professor Owen very kindly gave his attention to the fossils during the limited time I was in London, and made his determinations concerning them, though 'subject to correction.' They are regarded by him as belonging to a 'Saurian Reptile with an unusually thin and compact wall of bone in the limb bones, which, however, might have been occupied by unossified cartilage, as in the young crocodile and turtle; but if they were filled with oil or light marrow, it would point to a course of development towards Pterodactyles or Birds. This phrase is purely hypothetical, and I mean to express no more than a degree of resemblance, supposing marrow and not gristle to have filled the large cavities.'

"The most important characteristics of these fossils so far as determining the genus is concerned, are in the bones of the right foot, which are tolerably well preserved, and a drawing of which — of the natural size, in Plate ix, fig. 6 — has been made by my sister, Miss Emily Hitchcock. From this drawing it will be seen that the prominent character of the foot is the robustness of the pollex. Hence Professor Owen suggests the generic name *Megadactylus*. The only other terminal phalanx of this extremity, is found on the fourth toe. And it might possibly seem that there were no claws on any toe but the first one, were it not that among the fragments of the skeleton, another claw is preserved which is only about one-fourth the size of the one figured on the Plate.

"When the specimens were shown to Professors Owen and Wyman, it was thought that the foot was only four-toed, as a portion of the phalanges was covered by fragments of the rock. But close and careful work with the graver has uncovered the first and third phalanges of the fourth toe, seeming to show that the single phalanx on the right must have belonged to a fifth toe. Its greater size, also, shows that it could not have belonged to the fourth finger.

"In addition to the three phalanges of the fourth toe, a small bony knob was found, seeming to represent a fourth phalanx, or rudimentary claw. This, however, is so small, and the fragments of bone are so numerous throughout the rock, that it is possible it is only a bony fragment accidentally located in the position of a phalanx.

"For a specific name to this individual, I propose the name POLYZELUS, 'much sought for,' in allusion to the fact that for so many years other remains than simply tracks of the former inhabitants of the Connecticut valley, have been eagerly and anxiously sought for, and that now we have the much coveted bones."

Professor Cope's description, published in 1870, pp. 122A-G, follows:

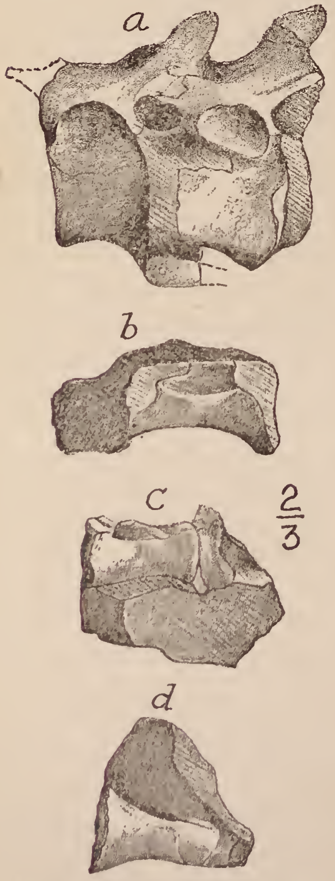

FIG. 14.—Vertebræ of *Anchisaurus polyzelus*. Two-thirds nat. size. After Cope.
a, anterior caudals; *b*, sacral; *c*, posterior caudal; *d*, dorso-lumbar.

"The remains consist of four caudal, and one dorsal vertebræ, the greater part of the left fore foot with distal portions of ulna and radius; the greater part of the left femur, proximal end of left tibia, greater part of left fibula, tarsus and hind foot, including a tarsal bone, perfect metatarsus, proximal end of a second metatarsus, parts of the distal end of a third, and parts and impressions of four phalanges. Also, the greater part of both ischia. . . . .

"*Vertebræ.* A dorso-lumbar is much compressed, but not keeled below; the articular extremities are expanded, and their faces slightly concave. An anterior caudal [*vide infra*] has a similar form, but the extremities are plane. The posterior basis of the neural arch is on the posterior third of the upper surface, and the anterior end has evidently supported its anterior part. They leave the median third of the canal open laterally, its median surface passing into the external over a lateral shoulder. The arch probably bridged over this interval.

The chevron bone is long and wide, and with thin walls. A second caudal exhibits similar characters. Two adjacent caudals in the same piece of matrix exhibit shorter, deeper centra, with strongly concave inferior surfaces, which are separated from the laterals by an obtuse longitudinal angle. Articular faces concave, forming vertical ovals truncate below. The chevron bones are narrower, directed backwards, and of very light construction. The neurapophyses present the singular character indicated above. Their contact with the centrum is anterior and posterior only, their basis being excavated upwards into a regular arch, whose margins flare out a little. This remarkable structure is only paralleled in the sacrum of other Dinosauria, where the nerves destined for the sacral plexus, issue through huge foramina in the bases of the neurapophyses. Here the structure is continued on the caudals, and evidently for a very different purpose. The neural arch has a high longitudinal carina, which is continued in the neural spine. It is concave on each side between the zygapophyses. The posterior zygapophyses stand above an intervertebral space, and the narrow neural spine rises above them, as is usual in Dinosauria. The zygapophysial faces make about an angle of 45°. A distal caudal is slender, sub-cylindric, and with low neural arch.

"The *right anterior foot* displays five digits, though one of them opposite the extremity of the ulna, was very short. The phalanges are, from without, ?-3-4-3-2; they are short and stout, the ungues short, deep, much curved and compressed. That of the interior digit is the largest; the inner edge is rounded, the superior broad and slightly flattened. At the middle of its length, a shallow groove near the dorsal outline begins to contract to a sharply defined, narrow groove, which continues to the end of the claw. The trochlear faces are well distinguished. The phalanges are stout and with a marked ligamentous pit on each side distally. The metacarpals of the two middle digits are slender and twice as long as the

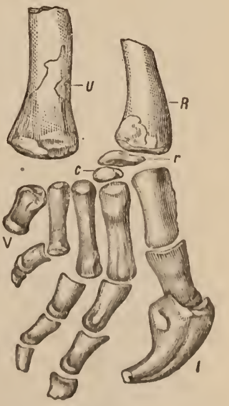

FIG. 15.—Right fore foot of *Anchisaurus polyzelus*. One half nat. size. After Marsh.

c, centrale; *R*, radius; *r*, radiale; *U*, ulna; I and V, digits one and five.

adjacent phalanges; that of the outer digit is one-third shorter, and that of the inner, one-half shorter than the median. The fourth metatarsus is longer than the external, but much more slender than any other. This finger was shorter than the third, and probably possessed three phalanges; portions of two are preserved, and the most distal is not ungual.

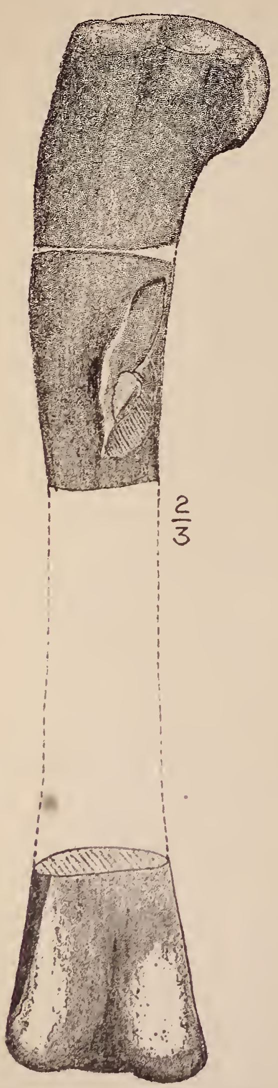

FIG. 16.—Femur of *Anchisaurus polyzelus*. Two-thirds nat. size. Modified from Cope.

"The extremity of the ulna larger than that of the radius and rather more expanded. Both bones of the forearm are very pneumatic, and oval in section.

"The *femur* is represented by both extremities with shaft adjacent, and that part of the shaft supporting the third [fourth, Dollo] trochanter. It is peculiar in presenting a combination of characters. The proximal extremity resembles that of the Crocodilia, while the distal is truly Dinosaurian, approaching Megalosaurus. There is no distinct head, the whole extremity is compressed, and the extremital surface concave in its long axis. It overhangs the shaft on the inner side and forms a knob which is decurved, and contracts below abruptly to the shaft. The external margin is a subacute ridge; the small trochanter is represented by a short ridge which is but little defined on the inner side, and which sinks to the general level some distance below the head. The compression of the shaft changes to a sub-cylindric form, and just above this point the large third [fourth] trochanter projects. It is short; inside of it a large rugose surface indicates the insertion of a powerful muscle. Near the distal extremity the shaft is compressed transversely. The articular face of the condyles is rather flat. The outer has a continuous exterior face. The inner is divided exteriorly, near the posterior extremity, by a deep groove, which is continued obliquely forward and inward on the articular face. The anterior part of this condyle is strongly convex. The posterior is narrow and turned inwards and backwards to a sharp edge. This portion is outlined by the above mentioned groove, and forms a narrow ovate [*sic*] in section. The popliteal groove is quite deep, and the trochlear scarcely marked.

"The *tibia* and *fibula* are broken. Of the first, a piece of the proximal portion alone remains; of the latter, a piece is broken from the middle of the shaft. The head of the tibia is flattened by pressure. The spine or crest is very prominent, but not so much so as in Lælaps, and is much curved outwards. The posterior angle of the proximal extremity is prominent, and the prominence to which the fibula is applied marks the anterior third of the long diameter of the head in its present condition. The anterior crest gradually sinks to the shaft. The greater part of the latter is flat, as an impression in the matrix indicates. The fibula is slender and oval in section, with very thin walls. At the distal extremity it expands slightly; the articular face is plane transversely, and moderately convex antero-posteriorly. Proximally the shaft expands in the direction opposite to its compression, giving the head a nearly equal extent in both directions. The articular surface is directed obliquely downwards to the tibia, and is more or less grooved; a strong rabbet extends round its posterior angle.

"The *foot* is in relation to the extremity of the leg, in a strongly flexed position. The tarsal and metatarsal elements were somewhat separated by the strain, though in nearly normal position.

"The *cuboid* bone alone remains of these. It is closely approximated to the fibula with a small interval occupied by matrix between. The form is somewhat like that in the genus Alligator, and it bears a similar relative size to the adjacent elements. It is a subtriangular piece with concave sides; the posterior angle, as it were, pinched. One lateral face, probably anterior, presents a longitudinal groove; one broad face, perhaps the external, a convex articular surface. The metatarsal face is slightly concave.

"The *metatarsus* which relates to the above, therefore the exterior, is much like that of the Alligator. The planes of the two extremities are nearly at right angles to each other. The proximal extremity is subtriangular with an external angle prolonged, and the posterior outline longest and slightly sigmoid. The shank has a large medullary cavity; the distal articular surface is sub-truncate, and the ligamentous pit very shallow, indicating absence of much flexure at that point. The convex external face of the cuboid, indicates the existence of a rudimental external digit in the usual place of the fifth; it may have been but a part of a metatarsus, as in the crocodiles. No trace remains. Two other digits have left their remains. Of these the median is so much larger than those on each side of it, as to render it probable that this animal possessed but three developed toes; in those types with a larger number, the two median at least, are of proportions more nearly similar to each other.

[Note. The foot probably contained three fully functional toes and one sub-functional hallux which would give the metatarsals the proportions noted by Cope. R. S. L.]

"One *phalange* of the middle toe is of a stout and somewhat compressed form. Two of the inner toe are more slender; the articular ligamentous pit is distinct in those of both, and the condyle convex, indicating extensive flexure. All are hollow.

"The disproportion between the lengths of the limbs is not readily ascertained; it is evidently not nearly so great as in the Lælaps, perhaps not greater than in many modern Lacertilia.

"*Ribs* are represented by several fragments, one perhaps a half. They display both capitular and tubercular articulations, the former apparently much the more extensive. The head and shaft of the ribs are compressed, and the capitular prolongation is as deep as the base of the shaft. The latter has a groove along its dorsal line for the proximal two-fifths the length. It is hollow, the medullary cavity being equal in diameter to the wall surrounding it.

"A Y-shaped bone with rather long stem has left an impression. The limbs of the figure are slightly unequal in length. Can it be a hatchet bone [rib] of the cervical vertebræ?

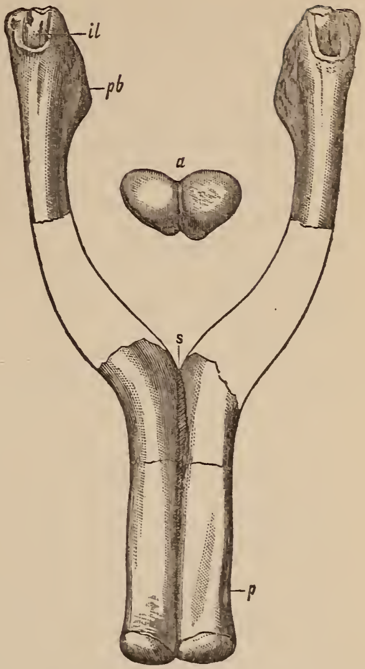

FIG. 17.—Ischia of *Anchisaurus polyzelus*. One-half nat. size. After Marsh.

a. distal aspect: *il*, iliac facet: *p*, distal end: *pb*, public facet: *s*, symphysis,

"*The pelvis* is only represented by a considerable portion of both ossa ischii. These indicate a remarkable peculiarity of the type, and explain the structure in Lælaps and some other Dinosauria. The portions preserved are the distal and median, with the impressions of the more proximal in the matrix. The former consists of two stout rod-like elements, having a triangular section, the superior and inner faces being plane, the exterior convex. The two interior are in contact throughout the straight portion of the bones. The extremity is convex and enlarged, especially downwards, and the two are separated by a deep groove, giving a section of the extremity the form of an ∝. At the point of divergence the stylus is flattened, while the divergent portions are more flattened, at first horizontally, then with a gradual approach to vertically. Like the other bones, they are pneumatic and thin walled proximally; at their medial portion they contain very light spongy cancelli.

"As compared with Compsognathus the caudal vertebræ are very much shorter and deeper: the extremities are stouter and more robust; the metatarsi and phalanges with ungues being shorter and thicker. . . . .

"No portion of the cranium or dentition of this genus has been preserved. The large stout hooked claws of the fore foot would indicate a more or less carnivorous diet."

Dimensions from Cope

Median caudal vertebra	
Antero-posterior length	21.5 mm.
Depth, articular face	23. mm.

Width, articular face	15.	mm.
Elevation of neural arch and spine	34.	mm.
Femur		
Length of proximal extremity	42.5	mm.
Width of proximal extremity	19.	mm.
Diameter of shaft	21.	mm.
Transverse width of condyles	40.	mm.
External metatarsus		
Length	70.	mm.
External metacarpus		
Length	11.	mm.
Length of third metacarpus	25.	mm.
" " second "	27.	mm.
" " first "	23.	mm.
Ungual phalanx; digit I		
Length	34.	mm.
Proximal depth	17.	mm.

Huene (1906, pp. 19-22) adds but little to the description offered by Cope as he only had Cope's figures for further study. He therefore contents himself with certain comparisons, notably with *Thecodontosaurus,* and a new interpretation of a few of the bones. The bone shown by Cope in fig. 6 [fig. 14,*b*] and described as an anterior caudal, Huene considers a sacral vertebra chiefly upon the ground of the length of its centrum and its difference of form from that of a typical anterior caudal. The two adjacent caudals in the same piece of matrix Huene thinks belonged near the beginning of the tail, but were not the foremost as the chevrons are too well developed.

To Cope's description of the hand Huene adds the presence of two carpalia, the smaller of which, lying above metacarpal II, he considers the trapezoid, and the larger a trapezium or radiale or intercentrum [centrale?]. The last interpretation he considers the most probable. Between the fifth metacarpal and the third digit lie three bones; the proximal one Huene considers only the distal fragment of metacarpal IV while the others he refers to as phalanges of digit V, which seems to me erroneous as they lie in position for those of digit IV, digit V being represented by the metacarpal only.

The ischia he considers similar to those of *Massospondylus;* they also resemble those of *Anchisaurus solus* in so far as common portions of each are preserved.

The femur as restored by Cope, Huene considers too long, and a sketch is inserted to show the proper length. (See fig. 16.) The fourth trochanter in position and character resembles that of *Thecodontosaurus,* but it also resembles that of *Anchisaurus colurus* though the position on the shaft seems to be somewhat higher. There is however a break between the portion bearing the fourth trochanter and either end in the *polyzelus* femur, while the entire length of the proximal end in *A. colurus* is not known; manifestly therefore the precise relative position of this trochanter in the two femora is a matter of conjecture.

Huene summarized the evidence as follows:

"These bones are similar in size to *Anchisaurus colurus* and Marsh makes *Megadactylus* also another species of *Anchisaurus.* The distinction from *Anchisaurus* seems to me, however, greater than from *Thecodontosaurus;* although the dorsals are lengthened in the same manner as in *Anchisaurus.* The femur with its probably high situated trochanter IV, the form of the tibia and of the fibula, and the radius and the slender metacarpalia as well speak more for the relationship to *Thecodontosaurus.* It is shown also that the anterior caudals have small dorsal spines like *Thecodontosaurus,* while *Anchisaurus* according to Marsh has broad dorsal spines."

Here I think Marsh's restoration is in error. In *Anchisaurus colurus* the caudals are unknown, that portion of the restoration being taken from *A. solus.* In the latter what I should call the sixth or seventh caudal shows a neural spine even smaller than those in the *polyzelus* caudals. Anterior to this the caudal spines in *solus* are obscure, but, if the caudals of *polyzelus* were the third and fourth (and as they bear chevrons it seems likely), the dorsal spines could readily grade into ones similar to those of *solus* when the sixth or seventh caudal was reached.

Personally, I do not agree with Huene in removing *polyzelus* from *Anchisaurus* to the European genus *Thecodontosaurus,* thus far unreported from the American Triassic, though possibly ancestral to the American genus. Huene evidently overlooks the fact that *polyzelus* is the type species of the genus *Anchisaurus,* and, if his contention be correct, the name *Anchisaurus* becomes merely a synonym for *Thecodontosaurus* and the species *colurus* and *solus* are left without a generic name.

Anchisaurus colurus Marsh

Marsh, O. C. 1891, Amer. Jour. Sci., (3) xlii, p. 267.

Marsh, O. C. 1892, Amer. Jour. Sci., (3) xliii, pp. 543-545, pl. xv, pl. xvi, figs. 1, 2.

Marsh, O. C. 1896, Din. of N. A., p. 148, pl. ii, figs. 1-3, pl. iii, figs. 1, 2, pl. iv.

Huene, F. v. 1906, Din. Aussereurop. Trias, pp. 6-13, pls. i-iii.

Type specimen, Cat. No. 1883, Yale Museum.

Locality. — Manchester, Conn., in the quarry of Charles O. Wolcott, about one mile north of Buckland station.

Horizon. — High in the upper series of sandstones, shales and local conglomerates, therefore geologically toward the close of Newark time.

Original Description. — "The new species is represented by perhaps the most perfect Triassic Dinosaur yet discovered, as the skull and greater portion of the skeleton were found in place, and in fine preservation. It is smaller than the specimen above described [*Ammosaurus major*], but similar in its general proportions, yet the two may be readily distinguished by the pelvic arch and posterior limbs. The pubes are distinct from each other, imperforate above, and the distal portions are only moderately expanded. The process that projects backward to meet the ischium is slender, and the face for union with that bone is quite small. The sacrum and ischia resemble those of *Ammosaurus* above described.

"The skull is of moderate size, and of delicate structure. In its general shape, it somewhat resembles the skull of *Hatteria.* The supra-temporal fossæ are very large, and the orbits especially so. The quadrate is inclined forward, and the upper and lower temporal arches are slender. Compressed, cutting teeth are present both in the premaxillary and maxillary bones. The lower jaws have similar teeth, and the rami are not united to each other at the symphysis in front.

"The vertebræ and limb bones are hollow, and the whole skeleton is lightly built. The neck is long, and the tail of moderate length [estimated, as it is not preserved. R. S. L.]. The scapula is elongate, and the coracoid very small and imperforate. The humerus has a strong radial crest, and the radius and ulna are nearly equal in size. There were five digits in the manus, the first, second, and third being armed with strong claws.

"The femur is longer than the tibia, and has a flattened head, somewhat like that of a crocodile. The tibia is short and stout, and the fibula well developed. The astragalus is not coössified with the tibia, and the calcaneum is distinct. There were five digits in the pes, but only four functional, the fifth being represented by the metatarsal alone.

"The skull of this reptile is about five and one-half inches long, and the lower jaw four and one-half inches. The scapula and humerus are of equal length, each about six inches long. The femur is about eight inches in length, and the tibia about six. The animal when alive was about five and one-half feet long."

In 1892 (pp. 543-545) Professor Marsh amplified the original description of this animal by the following details:

"The type specimen of this species, one of the most perfect Dinosaurs ever discovered, has now been worked out of the hard matrix in which it was imbedded, and the skull and limbs are represented in the accompanying plates.

"The skull was somewhat crushed and distorted, but its main features are preserved, and its more important characters can be determined with certainty. In Plate xv, figure 1 [fig. 18A], a side view is given, one-half natural size. One prominent feature shown in this view is the bird-like character of the skull. The nasal aperture (*a*) is small, and well forward. There is a large antorbital opening (*b*), and a very large orbit (*o*). This is elongated oval in outline. It is bounded in front by the prefrontal, above by the same bone, and a small extent of the frontal, and further back by the postfrontal. The postorbital completes the orbit behind, and the jugal, below. The supratemporal fossa (*d*) is large, and somewhat triangular in outline. The infratemporal fossa is quite large, and is bounded below by a slender quadratojugal. The quadrate (*q*) is much inclined forward. The teeth are remarkable for the great number in use at one time. Those of the upper jaw are inclined forward, while those below are nearly vertical. The lower jaw has the same general features of this part in the *Theropoda*.

" In Plate xvi, figures 1 and 2 [fig. 18 *B, C*] the same skull is shown, also one-half natural size. The top of the skull, represented in figure 1 [fig. 18 *B*], is considerably broken, and this has made it difficult to trace the sutures, but the general form and proportions of the upper surface are fairly represented. In figure 2 [fig. 18 *C*] only the back portion of the cranium is shown. The foramen magnum is remarkably large, and the occipital condyle is small and oblique. The basipterygoid processes are unusually short.

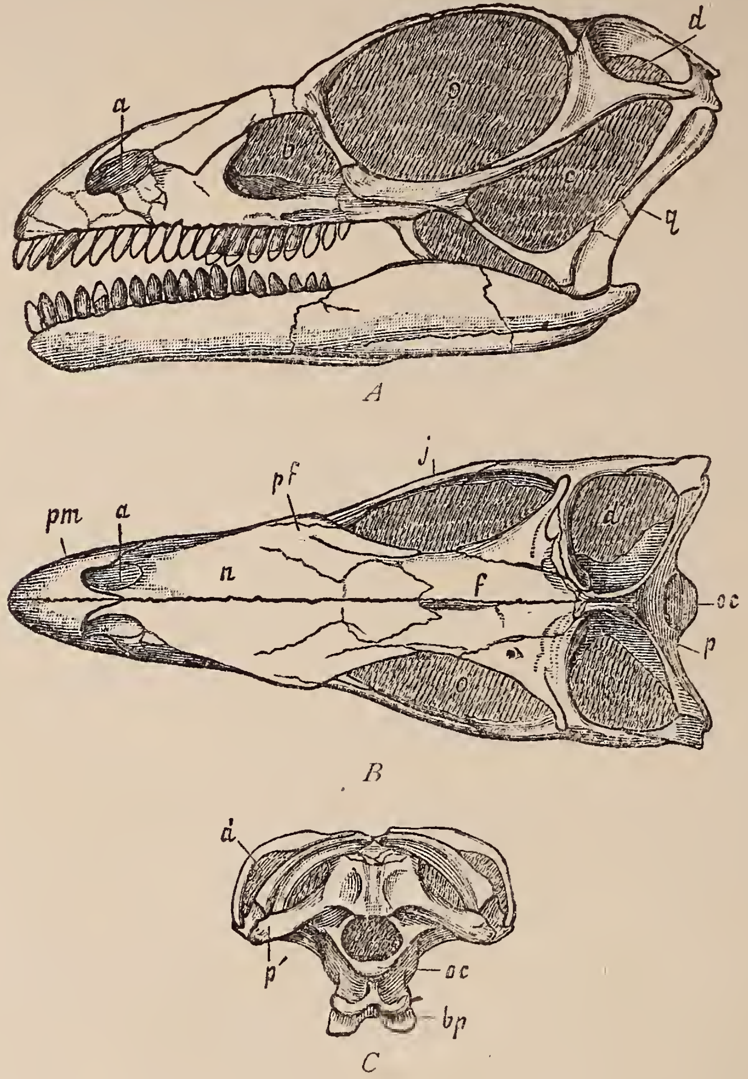

FIG. 18.—Skull of *Anchisaurus colurus*. One-half nat. size. After Marsh.

A, side view; *B*, dorsal view; *C*, posterior view. *a*, nasal opening; *b*, antorbital fenestra; *bp*, basipterygoid process; *c*, infratemporal fossa; *d*, supratemporal fossa; *f*, frontal; *j*, jugal; *n*, nasal; *oc*, occipital condyle; *p*, paroccipital process; *pf*, prefrontal; *q*, quadrate.

"The neck vertebræ are long and slender, and very hollow. Their articular ends appear to be all plane or slightly concave. The trunk vertebræ are more robust, but their centra are quite long. The sacrals appear to be three in number.

"The scapular arch is well preserved. The scapula, shown in Plate v, figure 2, *s* [fig. 19], is very long, with its upper end obliquely truncated. The coracoid (*c*) is unusually small, and imperforate. The sternum was of cartilage, some of which is preserved. The humerus (*h*) is of the same length as the scapula, and its shaft is very hollow. The radius and ulna are also both hollow, and nearly equal in size.

"There is but one carpal bone ossified in this specimen, and this is below the ulna. There were five digits in the manus, but only three of functional importance, the first, second, and third, all armed with sharp claws. The fifth (V) was quite rudimentary. The fore foot of the type species of *Anchisaurus* [*polyzelus*] is shown one-half natural size, on Plate xvi, figure 3 [fig. 15].

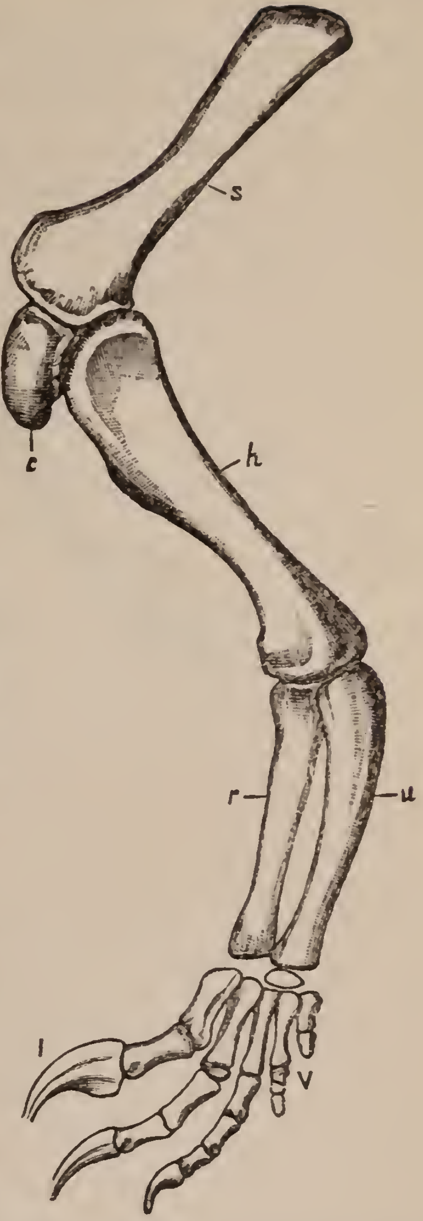

Fig. 19.—Left fore limb of *Anchisaurus colurus*. One-half nat. size. After Marsh.

c, coracoid; *h*, humerus; *r*, radius; *s*, scapula; *u*, ulna.

"The pelvic bones are shown in figure 3 of Plate xv [fig. 20]. The ilium (*il*) is small, with a slender preacetabular process. The ischia (*is*) are elongated, and their distal ends slender, and not expanded at the extremity. The pubes (*p*) are also long, imperforate, and not coössified with each other. The anterior part is a plate of moderate width. The ischia of the type species of this genus are shown on Plate xvii, figure 6.

"The femur (*f*) is much curved, and longer than the tibia (*t*). The latter is nearly straight, with a narrow shaft. The fibula (*f′*) when in position was not close to the tibia, but curved outward from it. All these bones have very thin walls. The astragalus (*a*) is small, closely applied to the tibia, and has no ascend-

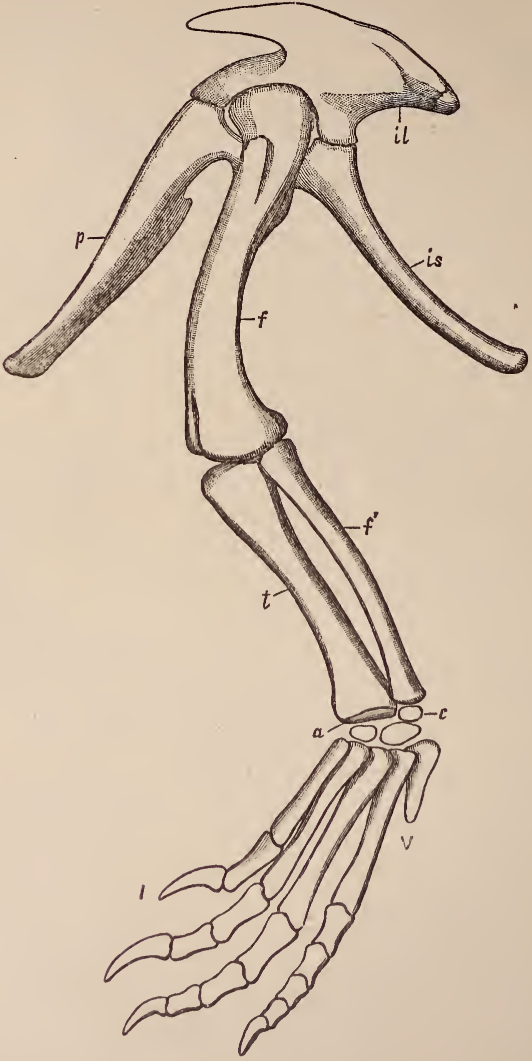

FIG. 20.—Left hind limb of *Anchisaurus colurus*.
One-half nat. size. After Marsh.

a, astragalus; *c*, calcaneum; *f*, femur; *f'*, fibula;
il, ilium; *is*, ischium; *p*, pubis; *t*, tibia; *I*, hallux;
V, vestige of digit five.

ing process. The calcaneum (*c*) is of moderate size, and free. There are only two tarsal bones in the second row.

"The hind foot has four functional digits, all provided with claws. The fifth was represented only by a rudiment of the metatarsal (V). The first digit was so much shorter than the second, third, and fourth, that this foot would have made a three-toed track very much like the supposed Bird-tracks of the Connecticut River sandstone."

In a paper entitled "Restoration of Anchisaurus" published in the *American Journal of Science,* (3) xlv, 1893, pp. 169-170 and plate vi, Professor Marsh throws additional light upon this interesting animal and its relatives by one of the admirable restorations which redound so much to his credit. This restoration is supposed to be that of the species under discussion, though, as the tail and part of the neck vertebræ were lost before the importance of the specimen was realized, such parts are supplied mainly from the smaller *A. solus* and from *Ammosaurus major* as well. Marsh says:

"The restoration as shown on Plate vi [fig. 21] indicates that *Anchisaurus colurus* was one of the most slender and delicate dinosaurs yet discovered, being only surpassed in this respect by some of the smaller bird-like forms of the Jurassic. The position chosen is one that must have been habitually assumed by the animal during life, but the comparatively large fore limbs suggest the possibility of motion on all four feet. The compressed terminal digits of the fore feet, however, must have been covered by very sharp claws, which were used mainly for prehension, and not for locomotion.

"The small head and bird-like neck are especially noticeable. The ribs of the neck and trunk are very slender. The tail apparently differed from that of any other dinosaur hitherto described, as it was evidently quite slender and flexible. The short neural spines and the diminutive chevrons directed backward indicate a tail not compressed, but nearly round, and one usually carried free from the ground."

Marsh's description was amplified greatly by Huene (1906, pp. 6-13, pls. i-iii), who published an excellent series of photographs of all of the Connecticut dinosaurian types.

Further Description. — *The skull.* The skull is nearly complete though quite badly crushed, nevertheless the limitations of most of the bones can be clearly distinguished though their position in relation to each other is only approximate. Huene published two photographs of the skull which purport to be natural size; in reality the length of the printed figure is 5.5 mm. too short. The figures are overlain by a transparent key for the identification of the bones which, while admirable, seems erroneous in indicating what is apparently the left frontal as the right. The anterior part of what Huene calls "Præfrontale sinistrale von innen" is the inner surface of the same bone he calls the lachrymal in the view from the left side. What he calls the left frontal is a slender process of bone which is seemingly continuous with the posterior portion of the prefrontal.

The premaxillæ are both fairly well preserved and not far removed from their normal position. Posteriorly each embraces a portion of the narial opening, which is oval with its long axis nearly parallel to the margin of the jaw. The hinder process for articulation with the maxilla is acuminate. But one premaxillary tooth is preserved, and in the present condition of the skull the number of dental alveoli is not discernible, though Marsh has restored seven teeth in the premaxilla. The length of this bone on the right side is apparently 19 mm.

The maxilla extends from about the mid length of the narial opening to beyond the posterior border of the antorbital fenestra. Anteriorly it sends a process forward above the premaxilla which bounds the lower posterior half of the nares. Dorsally it is broadly notched for articulation with the nasal bone which, however, is not preserved. The maxillary is extended posteriorly forming the lower limitation of the antorbital fenestra, sending inward the shelf-like floor to the fenestra as in *Allosaurus*. There is also evidence of a foramen piercing this inturned portion at the anterior angle of the fenestra as in *Allosaurus*. The number of maxillary teeth was eight to nine (Huene), though in Marsh's restoration twelve are shown. These have a broad lanceolate form with somewhat constricted cervix and rounded cutting edges which show no sign of crenations. The premaxillary tooth preserved is very suggestive of those of certain Sauropoda, and none of the teeth give evidence of the terribly aggressive carnivorous habits of the greater megalosaurs. The length of the right maxillary is 46 mm. and its depth as preserved 22 mm. The orbit is bounded below by the jugal, a slender triradiate bone, the ascending process of which articulates with the postorbital, while its posterior process, the preserved portion of which is extremely short, should reach a forward branch of the quadratojugal. Anteriorly the jugal articulates with the maxillary and according to Huene with the lachrymal as well, the latter forming the limitation between orbit and antorbital fenestra. The greatest length of the jugal as preserved is 34 mm.

The postorbital is another triradiate bone, this time with the three processes of nearly equal length. The antero-dorsal articulates with the well developed postfrontal by a long contact suture on its anterior margin and then continues on to articulate with the parietal, forming thus apparently all of the anterior limit of the supratemporal fenestra. The posterior process of the postorbital defines in like manner the inferior boundary of the supratemporal and the superior limitation of the infratemporal fenestra. Posteriorly this process fits into a notch between two forwardly directed processes of the squamosal, the combined structure forming the supratemporal arcade. Of the postorbital the greatest antero-posterior diameter is 40 mm. while the greatest dorso-ventral dimension is 34.5 mm.

The roof of the skull should show five pairs of bones. Of these I recognize but vague traces of the nasals. The prefrontals are ill defined, but on the left side there is preserved a portion of bone which forms the anterior half of the superior limitation of the large orbit, articulating in front with the lachrymal and dorsally with the frontal. The greatest dimension of this bone, its length, seems to be 28.5 mm.

The frontals show a considerable expanse, differing in this respect from the slender character of most of the other bones of the cranium. That of the right side is nearly gone while the left appears fairly well preserved except at its posterior end. It bounds the orbit little if at all, for the prefrontal extends nearly if not quite to the forward limit of the postfrontal. Its anterior margin is notched for the reception of the nasal bone, the apex of the notch being very near the mid-line of the skull. Posteriorly the frontal is destroyed. Whether it came in contact with the parietal of its side as Marsh shows or whether the postfrontal intervened I am not sure, but the better preserved postfrontal, that of the right side, seems to have met its fellow in the mid-line of the skull. The dimensions of the left frontal are: length as preserved, 26 mm., breadth, 7 mm.; of the postfrontal, greatest length, 27 mm.

The parietals are curiously curved bones nearly horizontal at their anterior end and twisted on their long axis through an angle of more than 90° so that the posterior face is visible from above. Anteriorly they articulate with the postorbitals and posteriorly with the supraoccipital while their externo-posterior portion articulates with the squamosal. Of course they form the inner limitations of the supratemporal fossæ. Their greatest length is about 33 mm., while from the middle line to the externo-posterior angle is about 19 mm.

Posteriorly the skull shows the occipital complex in articulation, except the left exoccipital which is displaced. The basisphenoid is approximately in position, though it seems to be bent upward on its longitudinal axis so as to pull the articulation with the basioccipital tubera somewhat apart. The occipital condyle is composed of a median basioccipital element and a lesser lateral portion from each of the exoccipitals. The latter show a number of foramina which Huene (1906, pp. 6-7) has identified as follows:

"The exoccipital process broadens at its base into three folds, one of which goes to the condyle. The second, really a branch of the first, is small and sharp and goes downward toward the tubera. Between these two first folds are found two foramina, one, somewhat larger, above in the angle of the fold, and one, somewhat smaller, beneath on the small fold; these two I consider the foramina hypoglossi (XII). . . . . The third fold is the chief ridge of the exoccipital process and is broad and strong. Between this and the second fold is found the large opening of the foramen lacerum and the foramen jugulare, and before this broad fold the opening of the canalis Fallopii (N. facialis, VII) must have been found as is the case in *Plateosaurus*."

The quadrate and squamosal are well developed, and the former is directed obliquely downward and forward as in Marsh's restoration, not vertically as in that of Huene (p. 10). The lower jaw is typical of the Theropoda and bore apparently eighteen teeth. There is no trace of the usual aperture through the surangular.

The Vertebral Column. — There are preserved eighteen presacral vertebræ, including two anterior cervicals which lay in the rock very near the skull. These are elongated, with low neural spines and strongly extended zygapophyses the articular facets of which lie nearly parallel with the longitudinal axis of the bone. The length of neither vertebra is preserved entire, but the anterior of the two now measures 37 mm., the posterior 56 mm. The centrum in each case is extremely hollow, the walls of the posterior one measuring 1.5 mm. thick. Long, slender cervical ribs, almost like those of *Compsognathus*, lie beside the centra and parallel to their long axis. The anterior one and a half vertebræ in the larger block Huene considers cervicals, and the following eleven dorsals, after which come three vertebræ concealed by the pubes before one comes to the first sacral, making fourteen dorsals altogether. Of these the anterior dorsals are shorter than the cervicals, but they again increase in length until the eighth, of which the centrum is 45 mm. long, after which they diminish again, the eleventh, which is the last visible one, being but 37 mm. long. These vertebræ are hour-glass shaped, for while the ends of a centrum measure 22 mm., across its middle section it is but 10 mm. broad.

The neural spines of the dorsal vertebræ are low and rectangular and that of the seventh measures 29 mm. long and about 15 mm. high. The centra show a longitudinal depression on either side which lightens them somewhat.

Marsh's estimate shows twenty-two presacral vertebræ as indicated by the numbering on the type specimen.

The ribs are long and slender, tapering to a very delicate extremity. The proximal end on the contrary is well developed, and so far as the ribs are exposed the capitulum seems always to articulate with the centrum of the vertebra, not rising onto the transverse processes as in some dinosaurs, notably *Stegosaurus*. The longest rib, that of the sixth vertebra, measures 206 mm. in length.

The Appendicular Skeleton. — The scapula of the left side is complete but seems to have a somewhat greater curve than in life. The proximal end is broadened, yet not markedly so when compared with later types, and the distal end shows a slight expansion, the posterior angle being distinctly acuminate. The length of the scapula measured on the curve is 147.5 mm., on the chord 123.7 mm., the proximal breadth 45.7 mm., that of the distal end 31.8 mm.

The coracoid is quadrilateral, somewhat thickened at its rounded postero-ventral angle. It shows no trace of coracoid foramen. Its length is 46 mm., its depth about 27 mm.

The humerus is broadened proximally and distally but the distal end especially is very thin. Neither the right nor the left is entire, the one showing the distal, the other the proximal end. Huene estimates the length from 180 to 190 mm. The width of the proximal end is 56 mm. while that of the distal end measures 48 mm. The radius is slender and the ulna broadened and the bones lie across one another in the rock. The distal end of the radius, however, seems displaced. The length of the radius is 92 mm., of the ulna 105 mm. At the distal end of the ulna lies a small ovoid carpal bone, probably the ulnare.

The hand is a splendid prehensile organ, especially in the power indicated in the first digit, the claw of which was large and sharply curved, and the entire finger shows evidence of great range of movement. The second and third digits are progressively more slender. Length of hand about 90 mm.; length of the first ungual phalanx 4.5 mm., its greatest breadth 2.2 mm.

The pelvic girdle is represented by the right ilium and both pubes; of the former only the acetabular portion with its two peduncles is exposed. In the restoration of *Anchisaurus* by Marsh is substituted the ilium of *Ammosaurus,* which Huene criticizes on the ground that it should resemble more nearly that of *Thecodontosaurus.* The antero-posterior breadth of the acetabulum measures 53 mm.

The pubis, Huene says, resembles partly that of *Plateosaurus* and partly that of *Megalosaurus.* The proximal end shows a distinct hook-like process, a rather narrow neck, beyond which the bone expands to a breadth of 50 mm. The distal end is somewhat thickened, but in common with other Triassic forms does not show the foot-like fore and aft expansion of the later Theropoda. The length of the right pubis is 183.5 mm., its proximal breadth 41.5 mm., the width of the neck-like portion 15 mm., and of the distal portion 30 mm.

The right hind limb is entire with the exception of the head of the femur, and is exposed on its posterior aspect, including the entire plantar surface of the foot.

The fourth trochanter of the femur is prominent and is situated 123.5 mm. from the distal end. The femur shows a distinct sigmoid curve and the distal condyles are well developed. The femoral length as preserved is about 210 mm., breadth of shaft 22.5 mm., of distal end 41.5 mm.

The tibia and fibula lie perpendicular to the bedding plane (the animal being supine) and seem to show a marked shortening due to pressure. It may well be that the bowing out of the fibula mentioned by Marsh is partially due to the same cause though *A. solus* shows it to some extent as well.

Tibial length including astragalus 14.7 mm.; breadth of proximal end 38.5, of distal end 43.5 mm. Length of fibula 127.7 mm. The flat astragalus, which has no ascending process, is closely applied to the distal end of the tibia, while the calcaneum is a much smaller, somewhat rounded bone.

Of the distal row of tarsalia two are preserved, which Huene identifies as the cuboid lying near metatarsal V, and the cuneiform III near metatarsal III. The foot is well developed and compact, and, while the hallux lies in the same plane as the other digits in the rock, if one may judge from the probable footprints, it was in life rotated to the rear so as to oppose the remaining digits as a powerful grasping claw. Metatarsal V is reduced to about one-half its functional length. Length of metatarsal III, 98 mm.; of digit III, 105 mm.

I have correlated (Lull 1904 A, p. 487) the footprint known as *Anchisauripus sillimani (dananus)* with the species of dinosaur under consideration, for both track and length of stride are just what the proportions of *Anchisaurus colurus* would lead one to expect. The footprint is one of the most common known in the Connecticut valley, and the species of dinosaur is the only one known from more than one specimen, as I have identified that found in 1818 at East Windsor (*vide supra* p. 77) as the same species. The latter specimen does not, however, add materially to our knowledge of the animal as it is far less complete than the type specimen.

Anchisaurus colurus was an alert, active dinosaur, preying upon the smaller vertebrates of his generation, as the powerful grasping claws and well developed teeth imply. While the actual remains are confined to the close of the Newark deposition in the Connecticut valley, the correlated footprints, being found first in the posterior shales, imply a longer career, though possibly not in the ultimate stage of evolution in which we know it. I believe the animal to have been entirely bipedal, never bringing the fore limbs to the ground even though their relatively large size would seem to imply it, for the imprint of the hand would be unmistakable and I have never seen in conjunction with the footprints of *Anchisaurus* or elsewhere such an impression. On the other hand, the imprints of the manus in the plant-eating orthopod dinosaur tracks are fairly common, but imply a hand of a totally different character from that of *Anchisaurus* (*vide infra* p. 207), resembling much more closely that of *Camptosaurus* of the Morrison, a well known predentate.

Restoration of Anchisaurus colurus. — The very well known restoration by Marsh (fig. 21), which has had wide acceptance in text-books and other publications, presents but few points to which in our more exact knowledge of the dinosaurs as living beings one can take exception. As the most salient point for criticism I would mention an apparent disproportion of limbs in that the fore limbs seem to be drawn slightly too great in size. There are also twenty-three presacral vertebræ, giving to the dorsal series one more than the two type specimens of *Anchisaurus* (*colurus* and *solus*) seem to show. The correction of these errors would tend to reduce in a measure the apparent top-heaviness for a bipedal gait. The tail seems somewhat short, though of this there is no true evidence other than analogy, for a long slender tail and a short heavy one may be equally efficient as a counterpoise, and the former is the type found in cursorial lizards, notably the bipedal ones (see also *Podokesaurus, infra* p. 167).

The tail also passes much too near the ischia at their distal end, a condition which would allow no room for a pelvic outlet for egg-laying or the evacuation of the alimentary canal.

The neural spines of the caudal vertebræ are restored like those of the presacral vertebræ. The evidence of the tail of *Anchisaurus solus* implies that they were quite small and low, a short distance from the proximal end of the tail. The final point of criticism is in the position of the hallux to which allusion has already been made.

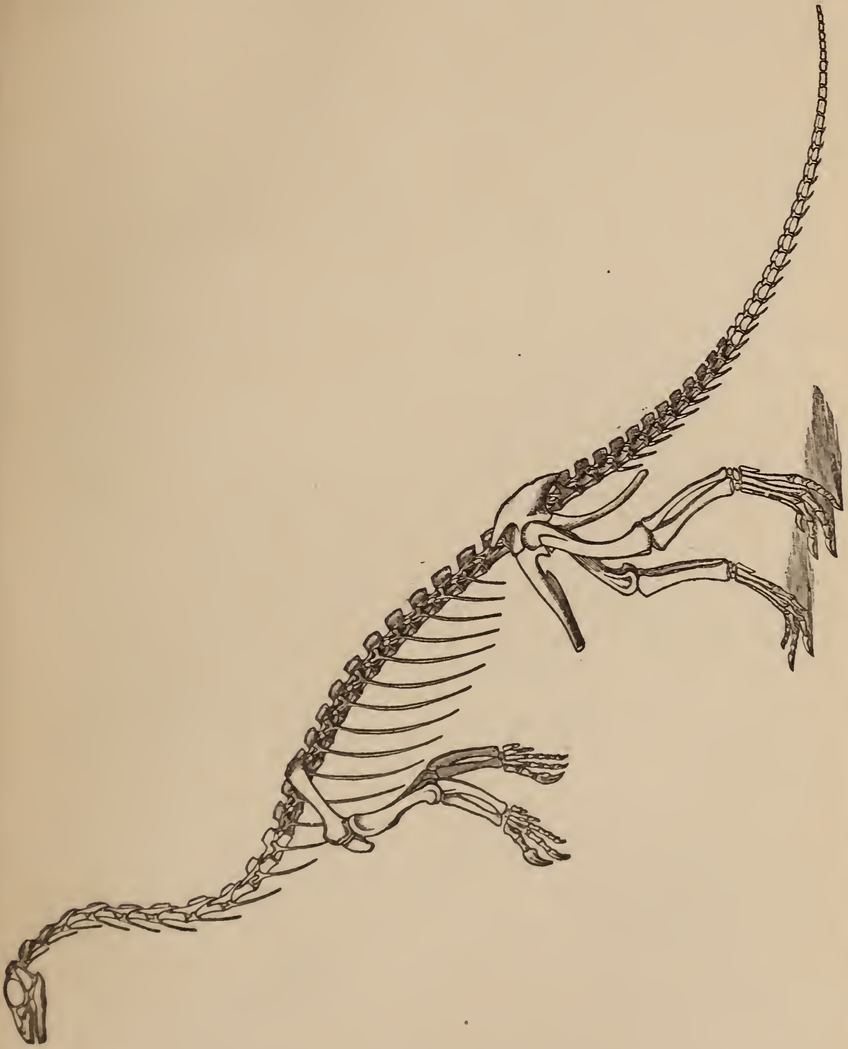

Fig. 21.—Restoration of *Anchisaurus colurus*. One-twelfth nat. size. After Marsh.

I offer as a substitute a new restoration made in the form of a model in the round, one side of which displays the skeleton, the other the animal in the flesh, an old idea but newly applied in prehistoric restorations in the hope that thereby the number of errors of interpretation would be reduced. Photographs of this model (Plates iv and x), which is one-third linear dimensions, are here presented for comparison with the classic restoration by my predecessor.

Anchisaurus solus Marsh

Marsh, O. C. 1892, Amer. Jour. Sci., (3) xliii, p. 545.

Marsh, O. C. 1896, Din. of N. A., p. 149.

Huene, F. v. 1906, Din. Aussereurop. Trias, pp. 14-15, pl. iv.

Type specimen, Cat. No. 209, Yale Museum.

Locality. — Manchester, Conn., from the quarry of Charles O. Wolcott.

Horizon. — Upper series of sandstones, shales and local conglomerates, about two feet higher and fifteen feet south of *colurus*.

Marsh's original description is as follows:

" A fortunate discovery has recently brought to light almost the entire skeleton of a diminutive Dinosaur, which may be referred to *Anchisaurus*, but clearly belongs to a distinct species. It was found in nearly the same horizon as the remains above described [*A. colurus*], and in the immediate vicinity, so there can be little doubt that it was a contemporary. The skeleton is imbedded in a very coarse matrix, so difficult to remove that the investigation is only in part completed. The portions uncovered show the animal to have been about three feet in length, and of very delicate proportions. The bones of the skeleton are almost all extremely light and hollow, but most of them are in fair preservation.

" The skull, so far as it can now be observed, resembles the one just described. The teeth are numerous, and inclined forward. The orbit is very large. The quadrate is inclined forward, and the lower jaw is robust. The entire skull is about 65 mm. in length, and the lower jaws the same.

" The neck was very long and slender, the first five cervicals measuring some 80 mm. in extent. The dorsals are also elongated, the last six covering a space of 135 mm. The number of vertebræ in the sacrum cannot yet be determined. The caudal vertebræ are short, the first ten occupying a space of 140 mm.

" The humerus has a very large radial crest, and is 66 mm. in length. The rest of the fore limb, so far as made out, is similar

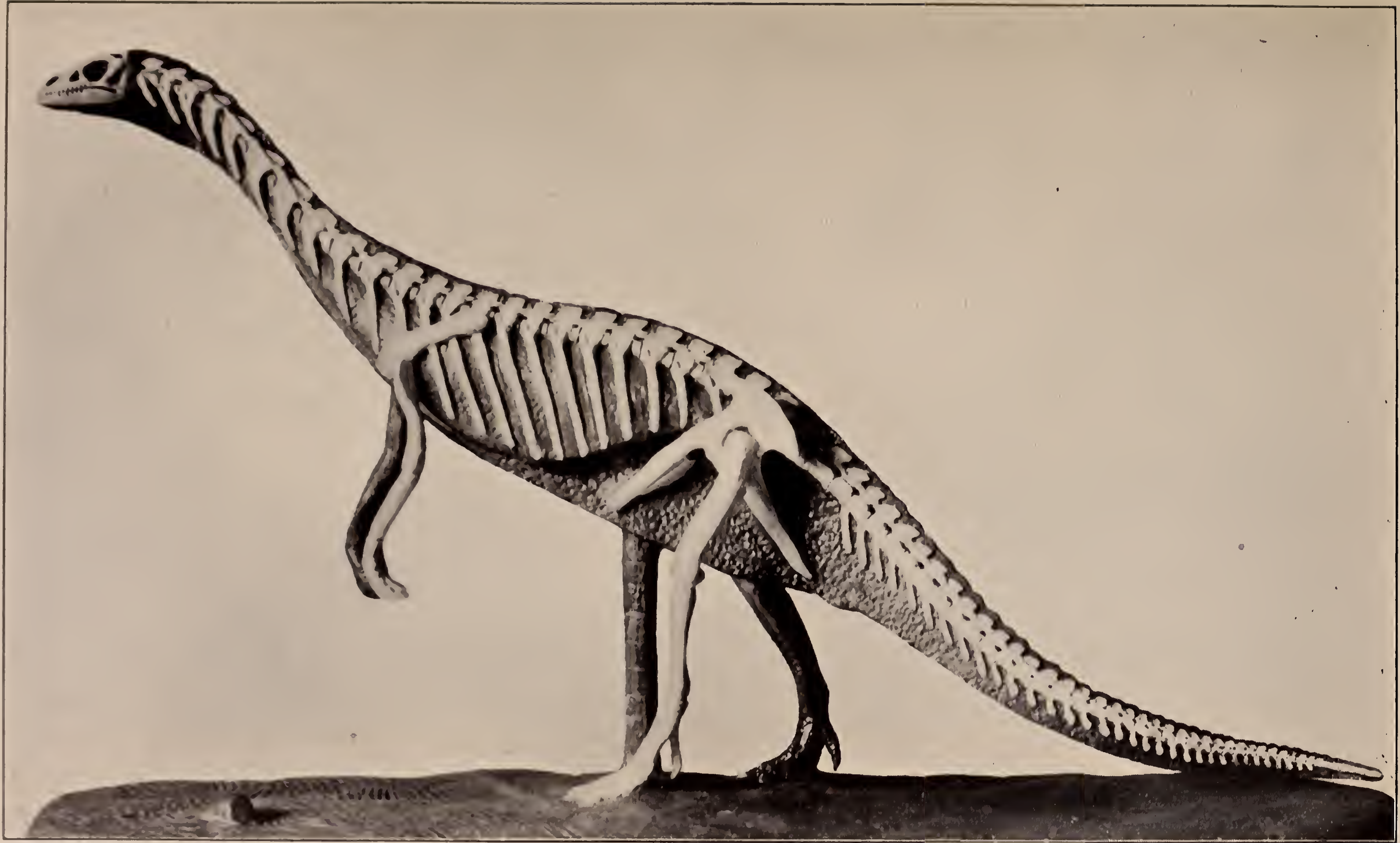

PLATE X. Restoration of *Anchisaurus colurus*. Skeleton. One-twelfth natural size. Original.

to those in the species described. The tibia is about 88 mm. in length. There were five digits in the hind foot, but the fifth is represented only by the rudimentary metatarsal. The animal when alive was about as large as a small fox."

Further Description. — The skull fragments, still embedded in the matrix, are of so very fragmentary a character that I can add practically nothing to what Professor Marsh has said; indeed it is difficult even to verify all of his statements. The dimensions he gives are correct.

The vertebral column shows apparently twenty-two elongated vertebræ, which together with the atlas make twenty-three as the total number of presacrals; of these Huene reckons nine as cervicals and fourteen as dorsals. The cervicals are extremely long and slender though apparently similar in proportions to the two anterior cervicals of *A. colurus* which are preserved. For the most part only the ventral aspect of the vertebral centra is visible with the exception of the anterior four or five cervicals, and they are so vaguely outlined as to be hardly describable. They seem, however, to resemble those of *A. colurus* above referred to in the elongated zygapophyses and vestigial neural spine. The posterior cervicals at least and the anterior one or two dorsals show lateral longitudinal keels demarking the limits of lateral ventral walls; in the other dorsals the keels become obsolete and the centra are more rounded. As in *A. colurus* the anterior dorsal (10th presacral) is shorter than the cervicals, beyond which the dorsals increase somewhat in length, the longest being the 9th (18th presacral) with a length of 21 mm. The 12th dorsal measures 20.5 mm. long by 9 mm. wide at the articular ends of the centrum and 5.5 mm. broad in its central portion, showing the typical contracted form seen in *A. colurus*. The ribs are exceedingly slender yet their length would indicate a full-bodied animal. The greatest preserved length, that of the 5th dorsal, is 85.5 mm. The sacrum unfortunately cannot be seen in the greatest degree of preparation which the specimen will safely

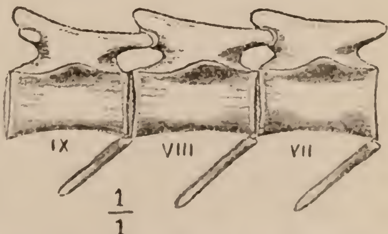

Fig. 22.—Caudal vertebræ of *Anchisaurus solus*. Viewed from the right side. Nat. size. Original.

bear, but the anterior ten (Marsh) caudals are visible on the lower side of the block. As I have said above (p. 129) in discussing the relationship of *A. polyzelus,* the shape of the neural spines resembles those of that species and is not of the character figured in Marsh's restoration of *Anchisaurus.* The centra are shorter than those of the dorsal vertebræ, that of the sixth measuring 17 mm. in length, while the seventh is 16 mm. long by about 15 mm. high including the neural spine. The caudal centra seem somewhat compressed laterally. This may in a measure be due to crushing.

Appendicular Skeleton. — Of the shoulder girdle but a trace is present, an indefinable fragment of what may have been the left scapula hidden beneath the bulk of the humerus. The latter is well preserved on either side, especially the left, and is particularly notable for the relatively high, almost bird-like proximal end with its expanded processus lateralis which narrows to a rather robust shaft, to dilate again at the distal extremity. The length of the left humerus is 67 mm., its proximal breadth 25 mm., width of shaft 6 mm., of distal end about 15 mm. As Huene says, it is short, but in comparison with the slender vertebræ is very robust and gives indication of a well developed musculature. The radius and ulna are also well developed. They lie in position, parallel to each other, the ulna being somewhat curved. Their length seems to be about 37 mm. In Marsh's statement that the hand had five digits of which the fifth is represented by the rudimentary metatarsal he must have reasoned from analogy, basing his description upon *colurus* and *polyzelus,* for the present specimen shows but one slender metacarpal, doubtless the fourth, beyond which lie portions of two phalanges, and toward the radial side of the hand the vestige of another phalanx, possibly ungual. There are rather vague impressions in the coarse rock which may have lodged other bones, but not sufficient in number or position to complete the manus as described by Marsh.

Of the pelvic girdle the right ilium is preserved together with both ischia, which, however, lack their extremities, and plate-like expansions which represent the pubes — all in their natural relative position.

The ilium is almost complete in outline. The entire acetabular outline for a chordal distance of 245 mm. is exposed. In front the ilium shows the long slender anterior process which Marsh considers characteristic of the family, but posteriorly the end is broken away so that the bone appears rounded. The dorsal outline of the bone is not preserved. So far as it goes this ilium agrees perfectly with that in Marsh's restoration of *Anchisaurus,* in spite of Huene's contention that that of *Ammosaurus* was used as a model. It may have been in part, but no one can disprove the correctness of the restoration from the evidence at hand. The ilium as preserved measures 46.5 mm. long by 264 mm. high.

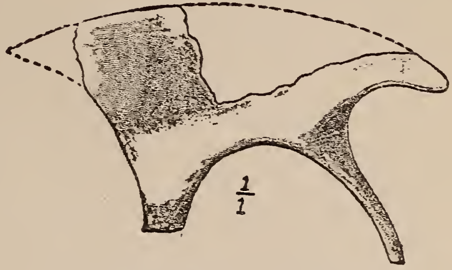

FIG. 23.—Right ilium of *Anchisaurus solus.* Nat. size. Original.

The pubes show the characteristic plate-like expansion in their mid-length seen in *A. colurus* but their outline as preserved is too vague for further description.

The ischia are well preserved except that their proximal end is buried in the matrix and their distal end destroyed. They curve downward and inward as in *polyzelus.*

The femur is well developed, very similar to that of *colurus* in outline and in the relative extent of the fourth trochanter. The bone is extremely thin-walled, that of the right being but 1.5 mm. in thickness in mid-shaft. The measurable length of the femur is 102 mm. which is probably somewhat less than its original dimension; Huene makes it 120-150 mm. The tibia according to Marsh measures 88 mm. The fibula of the right limb is exposed on the other side of the block, and lies some little distance away from, though parallel with the right tibia. This emphasizes Marsh's statement that in *Anchisaurus* the fibula is bowed outward from the tibia. This together with the breadth of the ankle would give a somewhat clumsy lower leg as a characteristic of the genus. The foot in so far as it is known resembles essentially that of *A. colurus,* but the third metatarsal is only half as long as that of *A. colurus,* which may be taken as indicating the comparative size of the feet in the two best known species of this genus.

My personal estimate of the length of *colurus* is about seven feet while *solus* was approximately half that size. The only footprint which I can correlate with this dinosaur is *Grallator tenuis*, a discussion of which will follow in the succeeding section (p. 201).

Genus **Ammosaurus** Marsh

Anchisaurus (in part)

Marsh, O. C. 1891, Amer. Jour. Sci., (3) xlii, p. 267.

This genus, which includes but one known species, *A. major*, was erected by Marsh subsequent to the specific description, when more material referable to *Anchisaurus* gave characters at variance with those of *major*. Marsh's discussion of the new genus is as follows:

" The Yale Museum has recently secured two interesting specimens of Dinosaurs from the Triassic sandstone of the Connecticut valley. In comparing these with the known species of *Anchisaurus* from this formation, the fact became evident that among them are two well-marked genera. One of the two specimens, which is described below [*Anchisaurus colurus*], cannot now be distinguished generically from the type of *Anchisaurus*, while the one described by the writer as *Anchisaurus major* is quite distinct, and hence a new genus is here established for its reception. The distinctive characters are well marked in the pelvic arch.

" There are three vertebræ in the sacrum, but they are not coössified with each other, being free, as in the Crocodilia. The ilium is comparatively small, and has a slender pre-acetabular process. The pubes are broad, elongate plates, perforate above, and not coössified with each other. In form, they resemble the corresponding bones in *Zanclodon*, where, however, the two are coössified, and imperforate. The ischia meet the pubes by an extensive union. Their distal ends are slender, directed backward, and closely adapted to each other. This species may now be known as *Ammosaurus major*."

Ammosaurus major Marsh

Marsh, O. C. 1889, Amer. Jour. Sci., (3) xxxvii, p. 331, fig. 1 (*Anchisaurus*).

Marsh, O. C. 1891, *Ibid*, xlii, p. 267.

Huene, F. v. 1906, Din. Aussereurop. Trias, pp. 15-19, pls. v-ix, fig. 1.

Huene, F. v. 1908, Din. Europäischen Trias, Lief. 5, p. 303.

Type specimen, Cat. No. 208, Yale Museum.

Locality. — Manchester, Conn., quarry of Charles O. Wolcott; with *Anchisaurus colurus* and *A. solus.*

Horizon. — Same as that of *Anchisaurus colurus.*

Original Description. — "The remains of this reptile are from the sandstone of the Connecticut River valley, which has long been known for the great variety of footprints it contains, especially those supposed to have been made by birds. The extreme rarity of any bones in these beds is equally well known, not more than half a dozen finds having yet been made, and only a few of these of much scientific interest. A portion of a skeleton found near Springfield, Mass., and described by Hitchcock, in 1865, as *Megadactylus,* has hitherto been by far the most important of these discoveries. It is a typical member of the order *Theropoda,* and has apparently for its nearest allies in the old world, *Thecodontosaurus,* from the Trias of England, and *Massospondylus,* from the same formation in South Africa.

"The remains here described represent a later discovery, in 1884, near Manchester, Conn., in essentially the same horizon as the Springfield specimen. They indicate an animal of larger size, but in many respects nearly allied to the one described by Hitchcock. Both apparently belong to the same genus, which the writer has called *Anchisaurus,* as the name first given was preoccupied.

"The present specimen is part of a skeleton which was probably complete, and in position, when discovered, but for want of proper appreciation at the time, only the posterior portion was secured. This consists of the nearly entire pelvic arch, with both hind limbs essentially complete, and in position. As this was one of the animals that are supposed to have made the footprints, one of the hind feet is figured below [fig. 25].

"In the present specimen there are only three sacral vertebræ. All the dorsal vertebræ preserved have their articular ends biconcave, or nearly plane.

"The ilium has a slender preacetabular process, thus differing from most of the other *Theropoda*. The ischia are very slender, and are directed backward. For the posterior half of their length, they are closely adapted to each other.

"The known remains of this species indicate an animal about six or eight feet in length."

The unfortunate loss of the anterior portion of this skeleton, which was built into the abutments of a bridge before the full value was realized, has already been described (*vide supra* p. 78). Professor Marsh tried in vain to locate the block containing the specimen, but, when it became evident that little short of the total destruction of the abutments might be necessary, the search was given up and the bridge still has the unique distinction of being the mausoleum of a dinosaur.

The portion collected includes the entire pelvic and sacral region together with the nearly complete hind limbs, practically articulated, and indicating that the animal died or at least was entombed in a peculiar squatting posture as though forcibly pressed downward from above. The bones are in good condition, parts of them wonderfully preserved, though there is some evidence of crushing, notably in the left femur and tibia. The resistant character of the coarse red sandstone renders inadvisable the entire freeing of the bones as is usual with material from this horizon.

Of the vertebral column six bones are present of which three constitute the sacrum while the remaining three are presacral. The presacral vertebræ are embedded in the matrix on their ventral side, so that little of the character of the centra can be seen. The neural spines are rectangular in shape, low and long, that of the penultimate vertebra being 37 mm. in length by 18 mm. high. The zygapophyses are well developed, their facets lying parallel with the longitudinal axis of the vertebra in its lateral aspect, but looking sharply inward on the part of the anterior zygapophyses and outward in the posterior ones.

The dorsal ribs preserved are relatively stronger than in *Anchisaurus,* that of the penultimate vertebra being distinctly flattened, partly, I imagine, due to crushing. The tuberculum articulates with the extremity of the transverse process so that the upper surface of the two bones appears essentially continuous.

The combined length of the posterior three of the presacrals measured over the zygapophyses is about 165 mm.

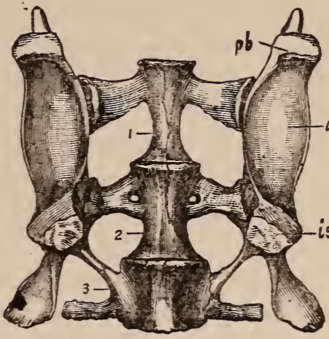

FIG. 24.— Pelvis of *Ammosaurus major*. ventral aspect. One-fourth nat. size. After Marsh.
1, 2, 3. sacral vertebræ; *ac*, acetabulum; *is*, ischial peduncle; *pb*, pubic peduncle.

The sacrals, the ventral aspect of which is displayed as well as that of the dorsal side, are, as Marsh has said, uncoössified so that, while closely applied to each other, a slight lateral and downward displacement has occurred between each two of the series. The centra are of solid construction, the anterior two being constricted medially like the dorsals of *Anchisaurus,* while the posterior one which is much shorter than its predecessors is broadened out into a peculiar form. In a like manner the sacral ribs, visible only from below, present peculiarities. The anterior rib arises from the extreme forward portion of its centrum and covers about one-third of the latter's length. Distally it broadens out and abuts against the ilium not far from the pubic peduncle, though its present point of contact is below that which it must have had during life. The second sacral rib has a broader origin, covering in this instance more than half of the length of the centrum though still attached to the anterior moiety of the latter. Ventrally it shows a pit-like depression at its proximal end so as to appear practically two-headed, while distally it tapers in a reverse manner to that of the first rib, and its point of contact with the ilium lies nearly opposite the ischial peduncle, so that the two anterior sacral ribs tend thus to reinforce the acetabulum and receive the thrust of the thigh. The sacral rib of the third vertebra is very peculiar; arising as it does from the *posterior* two-thirds of the laterally extended centrum it bifurcates widely, one limb passing outward and forward at an angle of 45° with the long axis of the vertebræ and abutting against the ischial peduncle not far from the insertion of the second rib. The posterior limb on the contrary runs upward and outward perpendicular to the axis of the centrum and meets the posterior portion of the blade of the ilium itself (see fig. 24). The dorsal spines of the sacrum are relatively higher than those of the presacral vertebræ and slant obliquely backward.

The length of the first centrum is 52 mm., of the second 48.5 mm., and of the third 37 mm. The length of the anterior sacral rib is 30 mm., its distal antero-posterior diameter 31 mm.; the same measurements of the second are 34 mm. and about 12 mm. respectively, while the anterior limb of the third measures 30 mm. and its posterior limb 37 mm. The only form known to me (or Huene) in which the last sacral rib is of this character is the sauropod *Brontosaurus excelsus* of the American Morrison. Marsh in his restoration of *Anchisaurus* shows the posterior sacral rib to be of this type. As this element is unknown in either of the *Anchisaurus* specimens, it must have been restored from *Ammosaurus* and is a possible source of error so far as the restoration of *Anchisaurus* is concerned. Its correctness or incorrectness, however, cannot now be proved.

The Appendicular Skeleton. — *The Pelvic Arch.* The right ilium is practically intact, while the posterior half of the left is destroyed. This bone is peculiar, as Marsh has said, in the very slender anterior process which arises at a sharp angle from the long, slightly curved pubic peduncle, similar to that of *Anchisaurus solus,* except that the angle is more acute, doubtless due in part to crushing in the present instance. Indeed the shape of the ilium under discussion resembles that of the type of the sauropod *Morosaurus lentus,* Cat. No. 1910, Yale Museum, more than it does that of the carnivorous *Creosaurus atrox,* Cat. No. 1890, Yale Museum, except that in *Morosaurus* the anterior process is broader and sharply twisted on its long axis, so that, presenting as it does an edge view when observed from the side, it heightens the apparent similarity between this ilium and that of *Ammosaurus.* What the significance of this is, taken in conjunction with the peculiar third sacral rib which so resembles that of *Brontosaurus excelsus,* I cannot say, but they seem to be what Osborn has called *homogenetic* characters, potentially derived from a common ancestor.

Posteriorly the blade of the ilium broadens so that its greatest depth is just anterior to the ischial peduncle. Posteriorly the blade seems to have terminated in an acute angle but there is no angle of demarcation between the posterior process and ischial peduncle. The length of the ilium was about 200 mm., its greatest height 81.5 mm., length of the anterior process 52 mm., and the antero-posterior diameter of the acetabulum 73 mm.

The pubes are broadened at their proximal end so as to meet at once in symphysis in the mid-line of the body. There seems to have been a large oval obturator foramen clearly outlined in the left pubis, more obscurely in the right one, behind which lies the roughened margin for articulation with the ischium. In *Anchisaurus*, it will be remembered, there is a hook-like process at the proximal end of the pubis, but the obturator foramen which is doubtless homologous with the area within the curve of the hook is not otherwise present.

Anteriorly the pubes of *Ammosaurus* continue, so far as they are preserved, in a flattened, blade-like shaft curved slightly in the vertical plane so as to be convex when viewed from below. The shaft of the right and that of the left pubis seem to have been in contact along their entire inner margin. The preserved length of the left pubis is 175 mm., its proximal width 85 mm., the greatest (transverse) diameter of the obturator foramen 48 mm.

The ischia differ from those of *Anchisaurus* in that they, like the pubes, are flattened, plate-like bones in their proximal portion though evidently thickening in the shaft which is preserved apparently for about half its length. The ischia seem to approach each other more anteriorly than in *Anchisaurus*. Much of their true character, however, is obscured by the matrix. The preserved length of the left ischium is 144 mm. and its proximal breadth 79 mm.

The femora are both somewhat damaged, so that in neither case is the entire length preserved, the distal end being lacking in each instance. In general form, so far as a comparison may be made, the femur of *Ammosaurus* resembles that of *Anchisaurus* except that the fourth trochanter does not seem to be quite so prominent. The head has a broad surface for the articular cartilage attachment, the bone at this point being again suggestive of the Sauropoda. There is, however, a reversed curvature as in *Anchisaurus,* though much less pronounced. Some of the loss of curvature may be due to crushing, as the femur lies in the plane of sedimentation. The preserved length of the right femur, actual bone and matrix impression, is 266 mm., breadth of proximal end 53 mm., and distance of fourth trochanter from proximal end 130 mm. The trochanter is, therefore, relatively low on the shaft compared with *Anchisaurus*.

The tibiæ are also in poor condition, and only the proximal end of one fibula, the right, remains. Proximally the tibia resembles that of *Anchisaurus colurus,* with a well developed cnemial crest. Externally it is flattened so that a distinct angle is formed between the outer and posterior aspects of the bone. Whether the fibula was bowed outward as in *Anchisaurus* is difficult to decide; certainly the axes of the proximal end of the two bones as preserved do not lie parallel to each other. Of the right tibia nearly the entire length is preserved, the distal end being somewhat broken, while of the left the reverse is true though the preserved bone is in this instance much the shorter of the two.

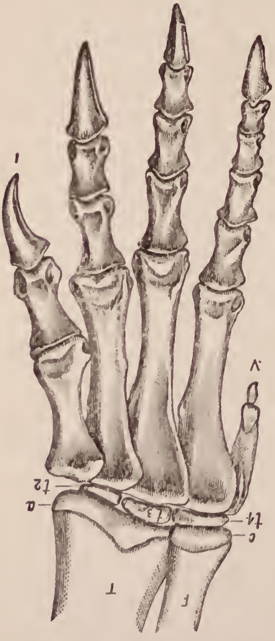

FIG. 25.—Right hind foot of *Ammosaurus major*. One-fourth nat. size. After Marsh.
I, hallux; *V*, digit five; *a*, astragalus; *c*, calcaneum; *F*, fibula; *T*, tibia; *t2-4*, tarsalia.

Length of right tibia as preserved 246 mm., antero-posterior diameter of proximal end 54 mm., width of shaft 100 mm., distance from proximal end 18 mm. Present antero-posterior diameter of crushed proximal end of right fibula, 30 mm.

The right foot has been figured by Marsh (fig. 25) with accuracy, except that during life the hallux was doubtless rotated to the rear as the correlated footprints (*Anchisauripus exsertus*) imply. The ungual of that digit is also sharply curved in the left foot, though straightened somewhat by pressure in the right, far too much curved for an ambulatory ungual. That the entire foot was a powerful grasping organ is forcibly shown by the present clenched attitude of the right foot due to post-mortem contraction of the flexor muscles of the leg.

The low astragalus without ascending process typical of the Anchisauridæ, is preserved together with the calcaneum, and what Marsh has identified as tarsalia 2, 3, and 4 of the second row, which Huene (1906, p. 18) calls after analogy with other forms the cuneiform II and III and the cuboid. The metatarsalia Huene says are not dissimilar to those of the Plateosauridæ.

Length of metatarsal I, 73.5 mm.; of II, 114.5 mm.; of III, 135 mm.; of IV, 130 mm.; of V, 61 mm. Length of first phalanx of digit I, 46 mm.; of the ungual, 48 mm.; of digit II, first phalanx, 44 mm., second, 31.5 mm., ungual, 51 mm.; of digit III, first, 45 mm., second, 37.4 mm., third, 30 mm., ungual, 35.7 mm.; of digit IV, first, 39.5 mm., second, 29 mm., third, 23 mm., fourth, 19.5 mm., ungual, 44 mm.

If the relative proportion of parts of *Ammosaurus major* were approximately that found in *Anchisaurus colurus,* the length of the former would be 8 feet 9 inches or 2.6 m. if that of the latter was 7 feet. *Ammosaurus major,* however, seems to have been somewhat the more robust of the two.

Superfamily *COMPSOGNATHA*

Family PODOKESAURIDÆ

Vertebræ and limb bones hollow. Pubes long and slender, ischia shorter. Femur shorter than tibia. Metatarsals long; manus and pes with three functional digits.

To this group of slender limbed, agile dinosaurs belong *Compsognathus* of the Solenhofen lithographic limestone (Middle Jurassic) and also apparently *Ornitholestes* from the Morrison (Upper Jurassic or Lower Cretaceous of Wyoming) and *Ornithomimus* of the Upper Cretaceous of Wyoming, Montana and Alberta. To these must now apparently be added a form which antedates all of the others in geologic time and which may prove to be ancestral to some at least of the later American genera. This animal is the latest accession to the growing list of osseous fossils of the Connecticut valley, and was found by Doctor Mignon Talbot, Professor of Geology in Mount Holyoke College, within a twelvemonth of this writing (1911). Years before the discovery of *Podokesaurus* the presence of dinosaurs of this character in the Newark rocks was suspected by the writer (Lull 1904 A, p. 544) who says in speaking of the ichnite genus *Grallator:*

"Another abundant genus is *Grallator,* characterized by very long limbs and small, compact feet without an impressing hallux and with no tail trace. The proportions of length of limbs to those of feet are the same as in the bustards, and the forms which made the tracks were probably aberrant carnivores of habits somewhat similar to those of wading birds, possibly feeding upon feebler reptiles and amphibians, or on fish. In considering the probable relationship of this genus to genera known from their skeletal remains one is reminded strongly of *Ornithomimus,* a Cretaceous compsognathoid dinosaur."

Genus **Podokesaurus** Talbot

Talbot, M. 1911, Amer. Jour. Sci., (4) xxxi, pp. 469-479, pl. iv, text figs. 1-6.

Type specimen preserved in the museum of Mount Holyoke College, South Hadley, Mass.

Locality. — In a glacially carried bowlder, not far from the site of Mount Holyoke College. The parent ledge must lie on the south side of the Holyoke range not more than two or three miles north of the place where the specimen was found.

Horizon. — Longmeadow sandstone in the "upper series of sandstones, shales and local conglomerates"; a contemporary of *Stegomus longipes* and probably of *Anchisaurus* and *Ammosaurus.*

Miss Talbot's original description follows:

"In a bowlder of Triassic sandstone which the glacier carried two or three miles, possibly, and deposited not far from the site of Mount Holyoke College, the writer recently found an excellently preserved skeleton of a small dinosaur the length of whose body is about 18 cm. The bowlder was split along the plane in which the fossil lies and part of the bones are in one half and part in the other. These bones are hollow and the whole framework is very light and delicate.

"As the fossil lies in the rock, most of the bones are in position, or nearly so, with the exception of the skull and tail. A detached tail that probably belongs to this specimen lies a few centimeters from the rest of the skeleton, and near it are three very thin bones that may belong to the skull (fig. 3, A, B, and C; Pl. iv, fig. 3) [fig. 26 and Pl. xi]. Two of these bones are bilaterally symmetrical and one of them is broadly convex with a well-defined median sulcus. They are all more or less embedded

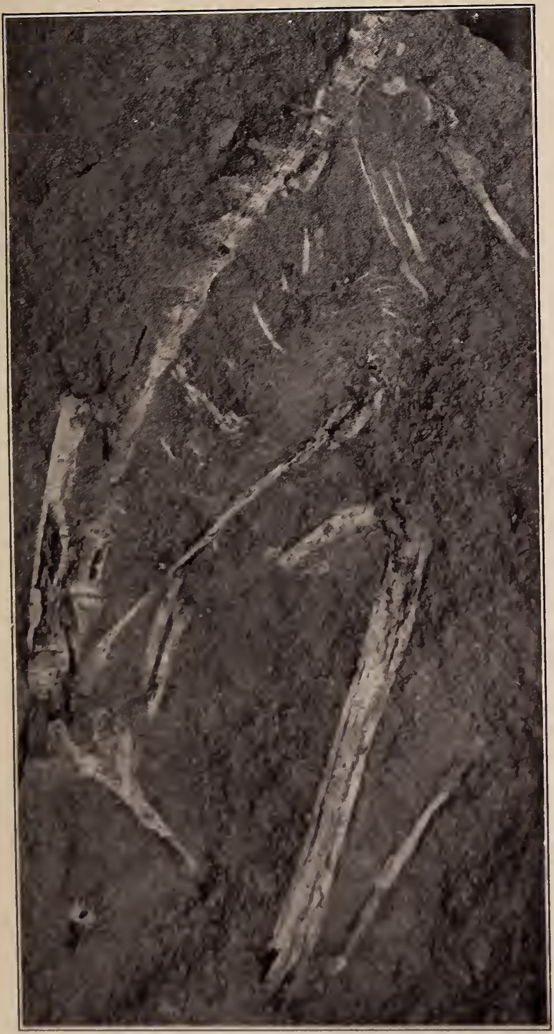

FIG. 1.

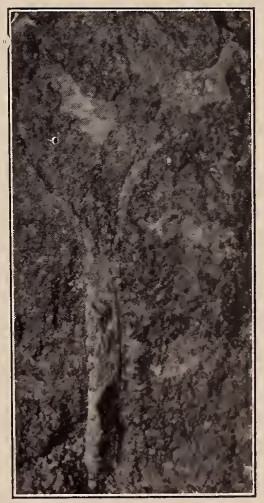

FIG. 2.

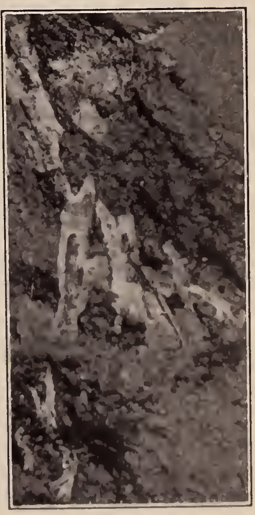

FIG. 3.

PLATE XI. — *Podokesaurus holyokensis*. After Talbot.

FIG. 1. — Skeleton. Two-thirds nat. size.
FIG. 2. — Pelvic bones. One and one-third times nat. size.
FIG. 3. — Skull bones (?). One and one-fourth times nat. size.

in the rock and cannot be described until the rock is removed. The other bones are better exposed and will be described below.

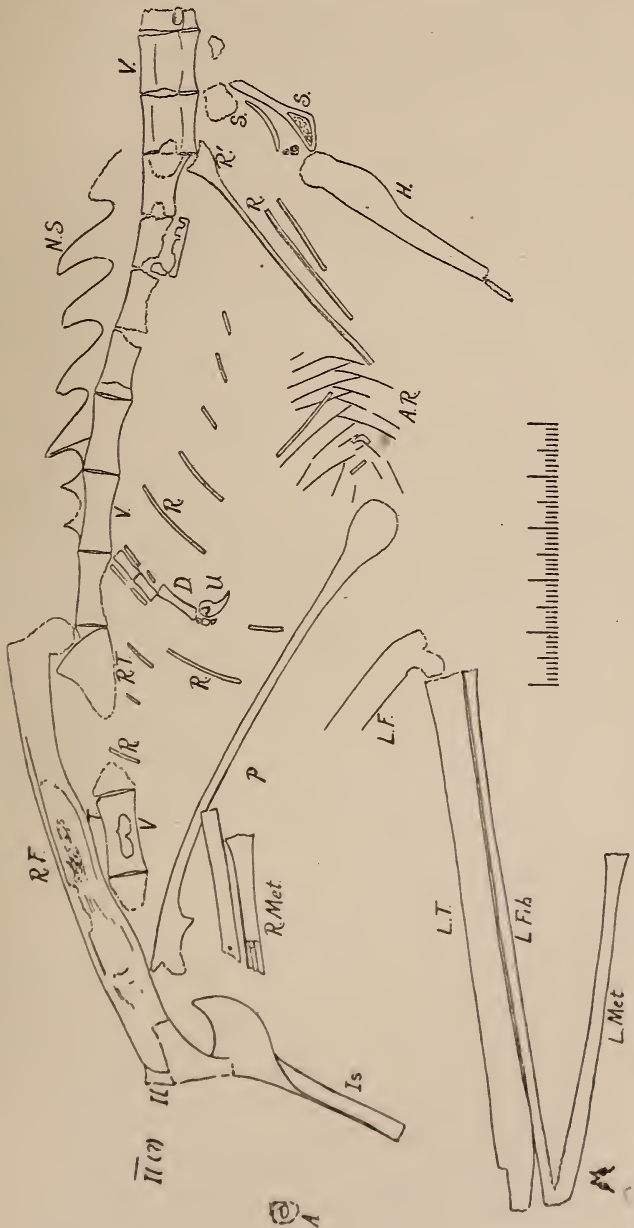

FIG. 26.—*Podokesaurus holyokensis.* After Talbot. *A*, astragalus (?); *AR*, ventral ribs; *D*, manus, *H*, humerus; *Il*, *Il*(?), fragment of right tibia; *Is*, ischium; *LF*, left femur; *LFib*, left fibula; *LMet*, left metatarsals; *LT*, left tibia; *NS*, neural spines; *P*, pubis; *R*, ribs; *R'*, proximal end of rib; *RF*, right femur; *RMet*, right metatarsals; *RT*, right tibia; *S*, coracoid and scapula; *T*, fourth trochanter; *U*, ungual; *V*, vertebræ.

"In the description which follows these features are to be noted: Light construction — hollow bones; slender, straight femur; position of fourth trochanter; position of fibula, lying close to the tibia; great length of tibia and metatarsals; small humerus; narrow shaft of ischium; great length of pubis; length of vertebræ.

"*Fore Limb.* — The humerus (fig. 1, H) [fig. 26] is a very delicately shaped bone, 42 mm. long (not quite half the length of the femur), slender and well rounded, with high radial crest. The proximal end shows a slight constriction above the crest, and below the bone tapers gradually to a diameter of 3 mm. at the distal end. Measured through the crest it is 8 mm. There is a trace of the impression of the radius or ulna just beyond the distal end.

"In the scapular region is a broad, flat bone, lying vertically in the rock, but twisted on its long axis at a right angle, midway of its length (fig. 1, S) [fig. 26]. This bone has a length, as shown, of 20 mm. and a width of at least 3 mm. Lying near its proximal end is another flat bone, 8 mm. long by 5 mm. wide. These may be three separate bones, more or less firmly united in the living animal. Further development is necessary, however, to bring out their outlines and their relation to each other.

"*Hind Limb.* — The femur (fig. 1, R. F. and L. F.) [fig. 26] is slender and nearly straight with thin walls. The bone is expanded on the back side at the distal end. The length is 86 mm., and the diameter, just distalwards from the fourth trochanter, is 6.5 mm. The fourth trochanter (fig. 1, T.) [fig. 26] is 18 mm. long and about 2 mm. high and is situated just beyond the middle of the shaft, toward the distal end.

"Only the proximal end of the right tibia (fig. 1, R. T.) [fig. 26] is exposed and there the bone is well rounded. This, however, may be only a small part of the proximal end, as the bone is embedded in the rock. The left tibia (fig. 1, L. T.) [fig. 26] is split lengthwise, part of the bone lying in each half of the bowlder. It is an almost straight, narrow shaft with the surface lying uppermost bent slightly at the proximal end, due, probably, to the expansion of the bone. In the position in which it lies, the bone is of nearly the same diameter throughout, about 7 mm. Its length is 104 mm. Lying close against the tibia and of almost equal length is the extremely thin fibula (fig. 1, L. Fib.) [fig. 26].

"There is a small, convex bone, 4 mm. by 6 mm., lying where the right tibia and metatarsals should meet, that may be the astragalus (fig. 1, A.) [fig. 26]. It shows no sign of an ascending process.

"Two of the right metatarsals (fig. 1, R. Met.) [fig. 26] lie in position. Their diameter is 2.5 mm. and 3.5 mm., respectively, along the shaft, but at the distal end there is an expansion to a diameter of 5 mm. In position, at the distal end of the left tibia there is one metatarsal (fig. 1, L. Met.) [fig. 26] slightly curved and 65 mm. long. Alongside are traces of a second. One of the digits (fig. 1, D.) [fig. 26], whose divisions are indistinctly shown, lies between two ribs not far from the right metatarsals. It is 20 mm. long and 1.5 mm. in diameter and is terminated by an ungual 7 mm. long. Cross sections of two bones near this one look like unguals.

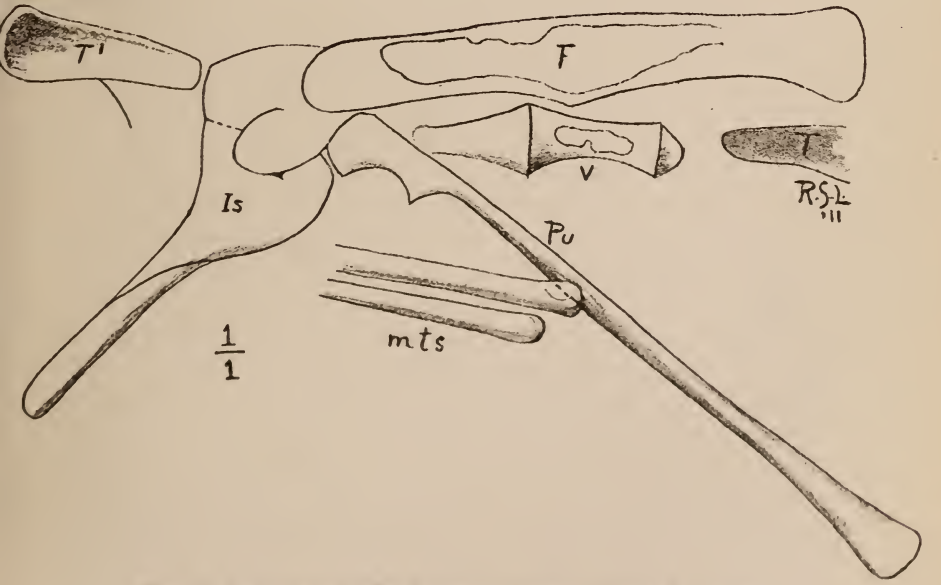

Fig. 27.— Pelvic region of *Podokesaurus holyokensis*. Nat. size. Original. *F*, right femur; *Is*, ischium; *mts*, metatarsals; *Pu*, pubis; *T*, T^1, tibia; *V*, presacral vertebra.

"*Pelvis.* — The pelvic bones are partly covered by the right femur and their outline is not distinct. What is probably the pubis (fig. 1, P., and fig. 2, Pu.) [figs. 26 and 27], is a remarkably long, thin bone, 95 mm. long, expanded at the distal end. The bone seems to be in position and makes an angle of about 40° with the line of the vertebral column. Its length is comparable with that of a new, undescribed form from northern Württemberg.

"The ischium (Pl. iv, fig. 2 [Pl. xi]; fig. 1 and fig. 2, Is. [figs. 26 and 27]) is well rounded, anteriorly, and has a shaft 4 mm. wide of which a length of 30 mm. is exposed.[1] The distal end is embedded in the rock. The contact with the ilium and the acetabular edge is obscurely visible.

"There is a bone running posteriorly from the head of the right femur which may be the posterior process of the ilium (fig. 1 and fig. 2, Il.) [*vide infra* p. 165], the anterior process being covered by the femur. This posterior extension can be traced indistinctly for 27 mm. and either points upward or continues the line of the posterior part of the vertebral column.

"*Vertebræ.* — Of the vertebræ there are visible seventeen presacral (fig. 1, V.) [fig. 26] and thirteen caudal (fig. 3, V.) [fig. 29], all very light and hollow, and some, at least, slightly concave at each end. The presacral vertebræ are slender, the measurements for the sixth presacral being 4 mm. through the middle of the centrum, 6 mm. at the ends and 15 mm. from end to end. A strong, gracefully curved neural spine (fig. 1, N. S.) [fig. 26] arises from the vertebræ in the dorsal region, about 10 mm. high and 12 mm. long at the base. The first two or three presacrals are a little larger than the others, and those at the anterior end of the column, much stronger. One of the latter measures 10 mm. at the end and the diameter through the middle of the centrum is only a little less. They are not so long, however, measuring only 12 mm. to 13 mm. One of these vertebræ is shown in cross section at a thin edge of the rock and has a transverse diameter through the cavity of the centrum of 4 mm. while the height of the cavity is 5.5 mm. (fig. 4) [fig. 28].

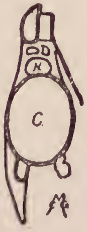

FIG. 28.
Cross section of vertebra of *Podokesaurus holyokensis.* Twice nat. size. After Talbot. *C*, centrum; *N*, neural canal.

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[1] The illustrations seem to indicate the presence of two bones, but this may be due to the presence of a ridge on the ischium, as is seen in Compsognathus.

"The caudal vertebræ are only a little expanded at the ends and are very slender throughout their length. A typical one is 17 mm. long with a diameter of 4 mm. at the ends. The neural spines, if such they are (fig. 3, D.-G.) [fig. 29], are of different shapes. These caudal vertebræ are so nearly of a size, one with another, that there is no apparent tapering of the series and it is not clear which is the proximal end of the tail, nor is it possible, as yet, to estimate its length [*vide infra*].

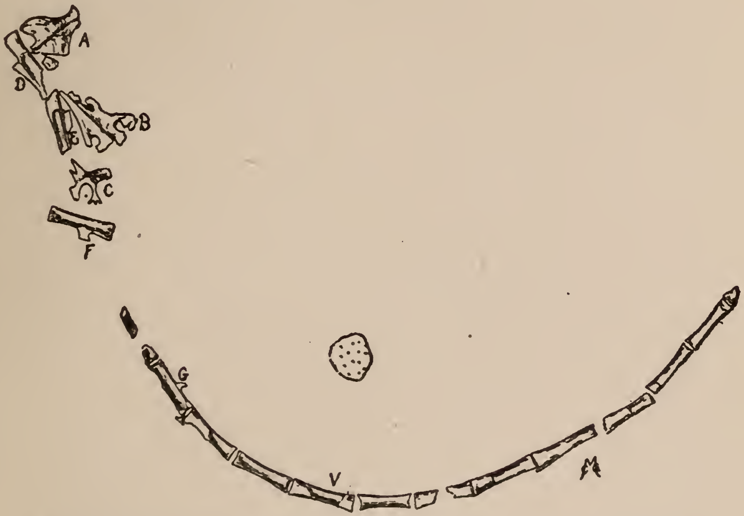

FIG. 29.—Caudal vertebræ and skull bones (?) of *Podokesaurus holyokensis*. After Talbot. A, B, C, possible skull bones; D, F, V, vertebræ; G, neural spine.

"*Ribs.* — Quite a number of ribs (fig. 1, R.) are visible, all very slender and hollow, but the proximal end is not exposed save in one instance where the bone is so broken that the outline is not distinct. Near this proximal end, however, the bone is somewhat concave and expanded as if it might be bifurcate (fig. 1, R.) [fig. 26]. The largest rib uncovered is 52 mm. long and 2 mm. wide toward the proximal end, while in no place does the thickness seem to be more than 1 mm. The most anterior of the cervical vertebræ preserved have long ribs. These are on another piece of the bowlder and are not figured.

"Just anterior to the distal end of the pubis there is a small cluster of gently curved abdominal ribs (fig. 1, A. R.) [fig. 26], exceedingly slender and dove-tailed as they lie in the rock, the position due, probably, to slipping. This mass of interlacing ribs covers a space of 40 mm. by 23 mm. There are at least eleven of these ribs on each side of the median line, the largest of which is 18 mm. long and so small in diameter that the bone looks like a mere thread in the rock. Slender as are these ribs, they seem to be hollow.

"*Sternal Element (?)*. — In the center of this mass of abdominal ribs is a small body that responds to dilute hydrochloric acid, as do all of the bones. The part exposed measures 5 mm. by 3 mm. This may be one of the sternal elements displaced.

"*Gastrolith.* — Lying 10 mm. away and still among these ribs, is a small piece of quartz, a flat, well-rounded pebble, 1 mm. thick and 10 mm. long. The width exposed is 4 mm., but more of the pebble is embedded in the rock. There are no other pieces of quartz larger than a grain of sand visible in the bowlder, and considering this fact, considering, also, its smooth, polished surface and its position, the writer concludes that this must be a gastrolith. This would seemingly be the first record of gastroliths found with carnivorous dinosaurian remains."

Doctor Talbot goes on to a comparative discussion of the points of *Podokesaurus* as contrasted with various orthopod and theropod dinosaurs. So far as classification is concerned, she interprets the fossil under discussion as a carnivorous dinosaur "because of the length, shape, and position of the pubis and the absence of a postpubis," and upon these positive and negative characters she rests her case.

Further Description. — Through the courtesy of the authorities of Mount Holyoke College the type specimen of *Podokesaurus* was loaned to the Yale Museum for further study and was placed in the skilful hands of the head preparator, Hugh Gibb, for development. The result of his labors, however, brought to light little that was new. It did serve to correct some earlier notions of interpretations, most of which Miss Talbot was able to avail herself of before the publication of her description.

The elements lying a little distance behind the body, which were supposed to be bones of the skull, proved to be mere flakes of bone which subsequent development did not serve to amplify.

One of the bones which the author speaks of as "bilaterally symmetrical . . . broadly convex with a median sulcus" may indeed be cranial as it is not identifiable as anything else. If so it is doubtless from the dorsal wall of the skull, the median sulcus representing the mid-line, which would place the element not far from the paired frontal bones of the cranium. The vague outlines were rendered no more distinct by further preparation (see fig. 29, A). Of the remaining bones, those at B and C may also be cranial as Miss Talbot has said; if so two of them (fig. 29, B) are apparently paired elements from the mid-line of the skull and as such can only be identified as nasals. An apparently symmetrically placed aperture through the broader posterior? portion of each bone is unknown in this element. The bone, however, is so thin a vestige of osseous material that accidental apertures are likely to occur where the bone is naturally thinner. For the odd bone C, I cannot suggest a location.

Vertebral Column. — The number of presacrals preserved is fifteen and a half (two and a half being in another block) of which I should call twelve dorsals and the remainder cervicals. There is, however, at least one more dorsal, possibly two, before the sacral series is reached, to be accounted for, making possibly fourteen dorsals and perhaps eleven cervicals including the atlas, giving in all at least twenty-four in the presacral series, compared with twenty-six in *Compsognathus* (Marsh's restoration) and twenty-eight in Osborn's estimate for *Ornitholestes.*

It is my impression that the "detached tail" of *Podokesaurus* really lies in its proper position with reference to the remainder of the skeleton and has not been pulled away, but merely that the missing vertebræ have been swept away, for in the neighborhood of the cranial elements already discussed there lie at least three detached caudals though probably not very far removed from their relative position. Scattered through the matrix and still more or less in the line of the tail lay other splinter-like bone fragments which may represent other débris of the tail. Miss Talbot remarks upon the uniformity of size of the articulated series of caudal vertebræ which makes it difficult to distinguish the proximal from the distal end. This is no longer true, however, for further development laid bare twelve more bones in the series, completing the tail distally. This would seem to imply a tail of great length which, because of its extreme lightness, would be necessary to serve as an adequate counterpoise to the forward part of the body, on the principle that an ounce weight at the end of a 17-inch lever would be as efficient as a pound at a distance of one inch from the fulcrum. I have therefore restored no fewer than forty-six caudal vertebræ, as compared with forty-four in *Ornitholestes* (Osborn) and ?thirty-seven in *Compsognathus* (Marsh). If this estimate be true, the preserved series of caudals are numbers 18-46, the scattered ones being all proximal to the continuous series.

The cervical vertebræ preserved are relatively large both in length and diameter as compared with the dorsals. Their neural spines are either not preserved or were extremely low, and the vertebræ were provided with the styliform cervical ribs characteristic of *Compsognathus*, none of those of *Ornitholestes* being preserved (I judge from the shading in Osborn's picture, Osborn 1903, fig. 1). The length of the centrum of the second preserved cervical (estimated ninth of the series) is about 21 mm.

The anterior dorsals are much shorter, after which the vertebræ again increase in length toward the pelvis.

The neural spines are high but not so extended antero-posteriorly as in *Compsognathus*, those of *Ornitholestes* being apparently imperfect. The transverse processes form the arc of a circle downward on either side extending about as far from the centrum as the spinous process is high. The zygapophyses are well developed but ill preserved as the bony matter is largely dissolved away. Relatively the centra of *Podokesaurus* are much longer than in *Ornithomimus;* on the other hand those of *Compsognathus* while still shorter than in *Podokesaurus* resemble them more nearly.

No sacral vertebræ are visible upon the specimen.

The caudals preserved are extremely long and slender, and, together with the preserved chevrons, resemble those of *Ornitholestes* quite closely. They are interesting in showing no diminution in length until the last few of the entire series are reached.

The proportions of the vertebral column as restored, measured on the curve, are; neck 130 mm., back 170 mm., sacrum 45 mm., and tail 730 mm., giving an estimated length of 1150 mm. (3 ft. 9 in.) for the entire animal including the head, as compared with 2220 mm. (7 ft. 3 in.) for *Ornitholestes* and 608 mm. (2 ft.) (Marsh's figure) for *Compsognathus.*

The ribs and abdominal ribs have been sufficiently described by Miss Talbot.

The Appendicular Skeleton. — The bone interpreted by Miss Talbot as a scapula seems to be in part at least the coracoid. This element, lying perpendicular to the plane of fracture of the rock, shows its cancellous inner texture within the thickened portion near the synarthrosis and glenoid fossa. The preserved part of the coracoid is 13 mm. high by 9 mm. in antero-posterior section. The remainder of the bone lying in the plane of fracture of the rock may represent the scapula but is indefinably obscure in outline.

The humerus is quite similar to that of *Ornitholestes* except that as preserved the radial crest is not so high. It gives by no means the sense of muscular power shown in that of *Anchisaurus solus,* which was doubtless a much more aggressive animal though showing far less cursorial adaptation than *Podokesaurus.* The manus of *Podokesaurus* is more *Compsognathus*- than *Ornitholestes*-like, but the latter is a rare specialization.

The pelvis is highly characteristic, particularly in the pubic bones, which resemble, as Doctor Talbot has said, those of a dinosaur from Württemberg, shortly to be described by Fraas.[1]

There is no trace of the ilium. That which the describer considered a trace of the posterior portion proves to be part of the right tibia, broken in such a way that the extremely thin wall outcropped in a slender line.

The pubis lies approximately in position[2], an extremely long bone expanding both at distal and proximal end. Seen edgewise as it outcropped from the matrix the shaft of the bone seemed

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[1] *Procompsognathus triassicus* Fraas, 1913.

[2] Herr Gerhard Heilmann of Copenhagen, to whom that portion of the present work describing *Podokesaurus* was submitted for criticism, says of my restoration of the animal (Fig. 31): "Professor Lull's placing of the pubis is not convincing, on the contrary, his description seems to make it still more probable, that this bone is entirely brought out of position, the ilium and the proximal end of the tail being totally wanting, and thus these must have been removed before the bones were covered by sand. Dr. R. W. Shufeldt supposes (in a letter) that the reptile may have been a subadult individual, and the prepubis not thoroughly coössified with the ilium and ischium in the cotyloid cavity. This seems very probable.

"A pubis protruding into the chest of the animal looks indeed too heterogeneous to be trustworthy." [Original author's translation, from Heilmann, 1913 B, p. 64.]

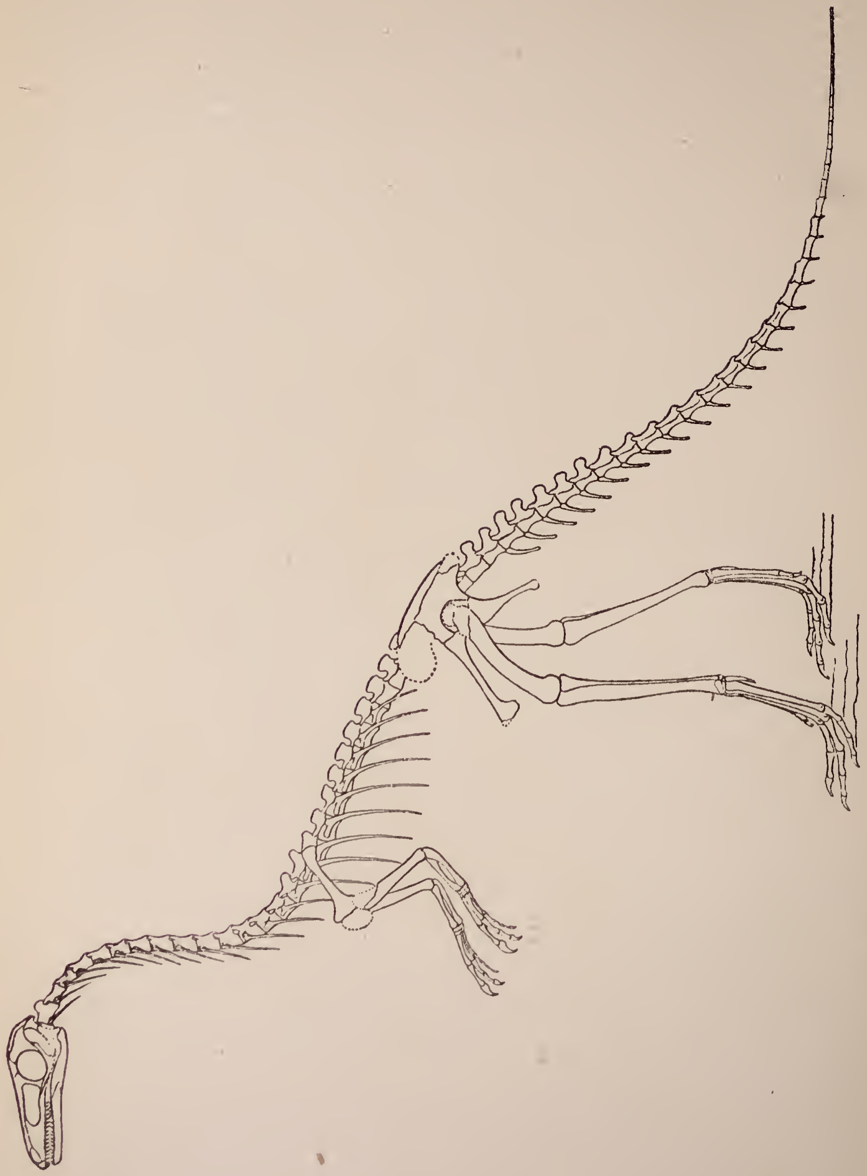

FIG. 30.—Restoration of *Compsognathus longipes*, of the Jurassic of Bavaria. One-fourth nat. size. After Marsh.

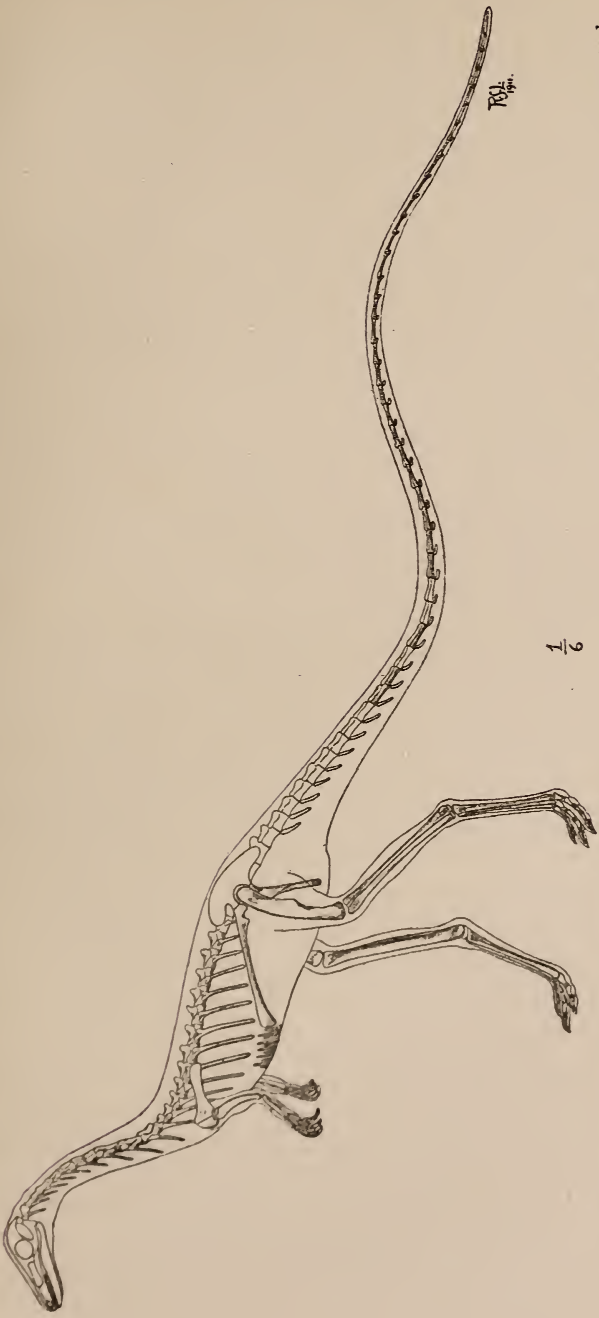

Fig. 31.—Restoration of *Podokesaurus holyokensis*. One-sixth nat. size. Original. The shaded areas are represented in the fossil, the other portions being restored from *Compsognathus*.

excessively thin, but further preparation of the specimen showed a width of at least 6 mm. in mid-length, and it may well be more, so that it shows something of the plate-like expansion of *Ammosaurus,* though with a process delimiting the proximal extent of the obturator notch as in *Anchisaurus colurus* rather than a distinct obturator foramen.

The entire length of the pubis is 95 mm. while the distal expansion measures 10 mm. in diameter. In *Ornitholestes* the distal end of the pubis unfortunately is not preserved so that its length appears conjectural. It has apparently, however, neither the angulation with the vertebral column nor the straight flattened shaft seen in *Podokesaurus.*

The ischium is essentially as described by Miss Talbot but has now been developed for its entire length. It measures 55 mm. long and 15.5 mm. wide at the proximal end while the shaft measures 4 mm. in diameter. This bone is more like that of *Compsognathus* than of *Ornitholestes* but does not show any very marked distinctions from either.

The femur, tibia and fibula are as described; further development however has exposed the metatarsals of the right leg, and they are so closely appressed together as to form a wonderfully compact structure, perhaps even more so than Marsh has described for *Ornithomimus* (1896 B, p. 204, pl. lviii, fig. 2 A). There is apparently even here no actual fusion into a cannon bone, which still remains a distinctive feature between dinosaurs and birds.

The metatarsals exposed are three in number with no trace of the first. It may have been present, however, though the digit was never even subfunctional if one may judge again from the correlated footprints. The length of the metatarsals is 75 mm. while the combined width of the three in mid-shaft is 9 mm. and that of metatarsal III alone 4 mm. One phalanx, the proximal one of digit III, measures 18 mm. long, the proximal end 6 mm. thick while the distal extremity is 4.5 mm.

I have compared the footprints of *Grallator cursorius* (see fig. 53) with the foot and stride of *Podokesaurus* with apparent conformity. *Grallator cursorius* is an abundant species associated in profusion with the huge *Otozoum moodii* from the quarry in

South Hadley, so that geologically and geographically as well as anatomically the comparison seems justified.

In my restoration of *Podokesaurus* (fig. 31) I have added the skull, ilium, and a few other missing details from *Compsognathus* which, while not contemporaneous, is a conservative type and of this group the nearest in time to the dinosaur under discussion.

Podokesaurus was essentially a slender, cursorial animal, carnivorous in habits, but from the very slenderness which gave it such celerity of movement necessarily confined to feeble prey of which the various Newark footprints manifest so great an abundance. That it was related to the group represented later by *Ornitholestes* and *Ornithomimus* seems approximately certain.

THE FOOTPRINTS

The various species of the vertebrate footprints owe their authorship very largely to President Edward Hitchcock, who described and named nearly all of the known forms from the Newark rocks, a labor which extended over a period of almost thirty years. To his son, Professor C. H. Hitchcock, much credit is also due, not only for the description of a number of new species, especially from the New Jersey area, but for his careful cataloguing of the great Amherst College collection and the gathering and arrangement of that at Mount Holyoke College as well.

A brief historical statement of the footprint nomenclature seems necessary in order to clarify the complex synonymy which has risen.

The first paper describing these phenomena in the Connecticut valley is that by Edward Hitchcock in 1836 — "Ornithichnology. — Description of the foot marks of birds, (Ornithichnites) on new red sandstone in Massachusetts;" Amer. Jour. Sci., xxix, pp. 307-340. In this publication Hitchcock says (p. 315):

"I include all the varieties of tracks under the term *Ornithichnites;* (ορνις and τιχνος [*sic*]) signifying *stony bird tracks:* and if it be convenient to speak of the subject as a distinct branch of knowledge, I should call it *Ornithichnology*.

"All the varieties of tracks which I have discovered, I include under two divisions: 1, the *Pachydactyli*, or thick toed: 2, the *Leptodactyli*, or slender toed. . . . . Under these divisions, I repose much confidence in the distinct existence of the following species and varieties. . . . .

" When I speak of species here, I mean species in oryctology, not in ornithology. And I doubt not, that in perhaps every instance, what I call a species in the former science, would be a genus in the latter; that is to say, these different tracks were made by birds that were generically different."

Then follows the first specific list; to be followed in its turn by descriptions of all of the species enumerated. This list reads:

" ORNITHICHNITES.

1. *Pachydactyli.*

O............ giganteus
O .... tuberosus
α dubius

2. *Leptodactyli.*

O............ ingens
α minor
O........... diversus
α clarus
β platydactylus
O............ tetradactylus
O............ palmatus
O............ minimus "

It should be here noted that Hitchcock clearly describes the species, but that the higher names are based on ideas, not on any specific specimen, *i. e.,* on " bird tracks," either " thick toed " or " slender toed." That this was his wish is also to be seen from his subsequent publications, cited beyond.

In 1837 the second paper upon the footprints appeared in the *American Journal of Science* (" Fossil footsteps in sandstone and graywacke "), xxxii, pp. 174-176. In it Hitchcock says:

" I am now prepared to describe fourteen new species — double the number described in my first paper. . . . . In general they are more distinctly marked upon the rock than those formerly described; and some of them bear in some respects so near a resemblance to the feet of living Saurians, that I have denominated them *Sauroidichnites*. But I have no certain evidence as yet, that any of them were made by four-footed animals, although in respect to two or three species I have strong suspicions that such was the fact. I have sometimes thought they might have been made by Pterodactyles. . . . . I take the liberty to subjoin a catalogue of all the species hitherto discovered, according to a more comprehensive arrangement, which further discoveries have rendered necessary. . . . .

"I arrange all the footmarks under the general term

ICHNITES (ιχνος and λιθος).

"The subdivisions are three.

1. *Tetrapodichnites.*
   T. didactylus.
2. *Sauroidichnites.*
   S. Barrattii [and other species].
3. *Ornithichnites.*"

In this paper no descriptions are given, but these are reserved for the article of 1841, the "Final Report on the Geology of Massachusetts."

On page 476 of the latter publication, under the title, "Classification," Hitchcock says:

"So numerous have been the discoveries of fossil footmarks in Europe within a few years past, and so many species occur in this country, that it will be at least convenient to have them designated by some appropriate scientific terms, and to arrange them in systematic order. I propose the term Ichnolite (ιχνος *a track,* and λιθος, *a stone*) to include them all; and to be the name of the Class. I would divide this Class into Orders, depending upon the number of feet possessed by the animal that made the tracks: *Polypodichnites* (πολυς, πους, and ιχνος) to embrace those with more than four feet: *Tetrapodichnites,* those with four feet; and *Dipodichnites,* the bipeds. . . . .

"I have arranged these species [Dipodichnites] under two sub-orders: the *Sauroidichnites* (Σαυρος, ειδος and ιχνος) or those *resembling the track of a Saurian, or lizard;* and *Ornithoidichnites* (Ορνις, ειδος and ιχνος) or those *resembling the track of a bird.* These names, implying only a resemblance, leave the real nature of the tracks open to discussion in the sequel."

The paper of 1845 read before the Association of Geologists and Naturalists at a meeting held in New Haven in April of that year establishes *genera* of fossil footprints for the first time; for, as Hitchcock says (p. 23), " hitherto names have been given to the footmarks and not to the animals. But since all geologists now admit that these impressions are real tracks, this paper attempts to name the animals that made them, and to classify and describe them, so far as it can be done from the data hitherto obtained. The following synopsis shows the names and the classification; the latter being merely provisional."

This paper was actually accompanied by descriptions of each of the sixteen genera and thirty-five species included in the list, but the descriptions were not published until 1848, when they appeared in the " Fossil Footmarks of North America." Nevertheless each species enumerated was accompanied by a clear indication of the one referred to under the older nomenclature, so that this series of names — with two exceptions wherein new specific names were substituted for the old, (*Eubrontes*) *dananus* for (*Ornithoidichnites*) *sillimani,* and (*Polemarchus*) *gigas* for (*Sauroidichnites*) *polemarchius,* which of course is unwarranted — must stand as a valid series of specific and generic names.

In 1848, in the publication just cited, Hitchcock again describes and figures the known sorts of footprints, but takes the liberty of changing the names (at that time the Candolle rules of nomenclature of 1844 had not been widely accepted) of certain of the genera and species proposed in the list of 1845, choosing to ignore that publication utterly, despite the facts that each name proposed was accompanied by a clear reference to previously described and figured species and that the vehicle of publication was an established journal of the highest rank. Such a procedure cannot now be followed, since the present rules of nomenclature are retroactive back to the publication of Linné's " Systema naturæ," tenth edition, 1758. The names in this 1845 list, therefore, cannot be considered *nomina nuda*, and according to the laws of priority[1] must stand, with the specific exceptions already alluded to. In all subsequent publications by Edward Hitchcock and his son, Charles H. Hitchcock, and others down to that of Hay in 1902, the later names of 1848 unfortunately were used and have become as a consequence the familiar ones.

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[1] "The valid name of a genus or species can be only that name under which it was first designated in the condition:

"a. That this name was published and accompanied by an indication, or a definition, or a description" (Internat. Rules Zool. Nomenclature, Art. 25).

"The word 'indication' in Art. 25a is to be construed as follows:

"(B) With regard to *generic* names . . . a definite citation of an earlier name for which a new name is proposed" (*Ibid.*, Opinion 1 B).

Hay in this work of 1902 made the first attempt at a revision of footprint nomenclature according to the present International Rules. So carefully was his work done that the writer has followed it closely, except where study of the actual tracks has brought to light new facts bearing on the synonymy; and it is hoped that the necessity for further literary revision of the nomenclature will be avoided. The carefully rendered advice of Professor Charles Schuchert and Doctor W. H. Dall, both of whom are high authorities in matters of nomenclature as defined in the International Rules, has been followed to the letter, and the weight of their sanction, coupled with that of Doctor Hay, seems sufficient to justify the generic and specific names used in this memoir.

The admirable revision of the genera and species by Doctor Hay in 1902, together with that of the author in 1904, the latter the result of several years' labor upon the collections at Amherst and Mount Holyoke, seems to obviate the necessity for more than a diagnostic review of the genera and species at this writing. I have endeavored, however, to figure each available species of vertebrate footprint found in the Connecticut valley and in New Jersey, while of the invertebrate trails only the most characteristic genera are thus treated. It is to be regretted that the vast Marsh collection at Yale is not at present accessible for study though many of the more easily handled slabs have been identified and catalogued. It is doubtful whether this collection would add materially to the list of species, though it would probably prove of the highest importance in the further elucidation of forms already named but obscurely known.

It has been deemed wise, even where with fair assurance one can correlate the tracks with the osseous remains of the animal that made them, to keep the ichnite genera and species apart in their nomenclature from that applied to the actual bones, for it is at once apparent to the student of ichnology that footprint genera and species do not necessarily correspond in limitations or numbers with those of the actual animals which made the impressions. The genera *Anchisaurus* and *Ammosaurus*, for example, though generically separable in the bones, made tracks which according to ichnological criteria can only be distinguished specifically; and I am quite sure , when I study the range of variation within the footprint species *Anchisauripus sillimani* (*Brontozoum sillimanium*), that more than one osseous form is required to account for it. One must always consider, too, the element of just scepticism with which any correlation of tracks and bones may be met, unless, as in the case of the Old World *Iguanodon,* the two are in exclusive association with each other.

Thus, even though in certain instances two names do apply to one animal, the avoidance of confusion and the greater approximation to facts justify what would otherwise be an unwarrantable practice.

In the classification I shall depart but little from that given in my earlier work of 1904 though a few corrections must of necessity be made. The tracks, the position of which may be given with approximate correctness, are taken first, the obscurer groups last. The definitions of course refer entirely to the footprints themselves.[1]

Class **REPTILIA**

Order **PARASUCHIA**

Suborder **AËTOSAURIA**[2]

Track Characters. — Small, quadrupedal, manus with 5 digits though all may not impress. Pes with 4 digits, semi-plantigrade. Stride generally long and trackway narrow. Claw of pes acuminate.

Family BATRACHOPODIDÆ

Genus **Batrachopus** E. Hitchcock

E. Hitchcock 1845, p. 25.

Anisopus E. Hitchcock 1848, p. 226.

Anisichnus C. H. Hitchcock 1871, p. xxi (to replace *Anisopus* preoccupied).

Generic Characters.— Manus probably with 5, track always with at least 4, broad clawless digits, generally directed forward. Pes 4-toed; hallux non-rotated, digits with slender acuminate claws, of which the fourth may be absent in the impression, possibly also in the foot. Third toe the longest. Manus and pes close together, nearly in a right line. Ratio of track to step about 1 : 7.

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[1] Unless specific statement to the contrary is made, the horizon of each footprint species is understood to be in the upper series of sandstones, shales and local conglomerates.

[2] *Vide supra* p. 99.

This genus is thus discussed by Hitchcock (1858, pp. 62-63):

"The tracks of the Anisopus have certainly very much of a Loricoid or Crocodilian aspect. I mean so far as the form of the foot is concerned. . . . It would seem, then, from these characters that we have in the Anisopus minute species of the crocodile tribe.

"But there is another character that makes it quite sure that they could not have had the structure of crocodiles, alligators, or gavials, or any of the scaly lizards; and that is the position of their tracks when walking. These succeed one another usually almost in a right line. . . . Now such an arrangement of quadrupedal tracks can be made only by an animal walking upright and with long legs. No existing lizard, batrachian, or chelonian, could walk in this manner. But the cat, dog, fox, etc., do leave tracks thus arranged. All the reptiles above named must leave two rows of tracks wide apart. And therefore, we have a strong presumption in such rows of tracks, that the animal which made them must be of the mammiferous class. The inequality of the front and hind feet points us to the marsupials among the mammifers; and since these appear to have been the earliest of this class that appeared on the globe, they are the ones most likely to have made the tracks. But although the marsupial type must have predominated, the loricated or crocodilian characters, already indicated, ought not to be overlooked, and, therefore, I call the animal a *Loricoid Marsupialoid*."

In placing this group of tracks under the Proterosauria of Seeley, in 1904 A (p. 482), I had in mind the long-limbed *Kadaliosaurus* from the Permian of Germany as possibly suggestive of affinities; but the discovery of *Stegomus longipes* Emerson and Loomis, described above (p. 102) from the same general horizon and locality which produced the footprint, supplied a form which would serve for the interpretation of the genus with little chance of error (Lull 1904 C, pp. 381-382).

Batrachopus deweyi E. Hitchcock

Sauroidichnites deweyi E. Hitchcock 1843, p. 261, pl. 11, fig. 9.

Batrachopus deweyanus E. Hitchcock 1845, p. 25.

Anisopus deweyanus E. Hitchcock 1848, p. 226, pl. 16, figs. 5, 6; 1858, p. 60, pl. 9, fig. 3; pl. 41, fig. 2; pl. 43, figs. 1-2; pl. 53, fig. 8; pl. 58, fig. 11.

Lull 1904 A, p. 483.

Type specimens, Cat. Nos. 26/5 and 26/6, Amherst collection. Type locality unrecorded.

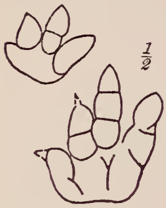

Fig. 32.—*Batrachopus deweyi.* One-half nat. size. Original. Small specimen.

Specific Characters.[1]—Manus: Length of digit I, 8 mm.; II, 20 mm.; III, 25 mm.; IV, 25 mm.; V, 15 mm.; distance between lateral claws, 19 mm. Divarication of digits I and II, 53°; II and III, 13°; III and IV, 18°; IV and V, 24°; I and V, 107°.

Pes: Length of digit I, 25 mm.; II, 38 mm.; III, 43 mm.; IV, 38 mm.; entire foot, 43 mm. Divarication of digits I and II, 12°; II and III, 23°; III and IV, 6°; I and IV, 40°.

Length of step, 100 to 113 mm. Width of trackway, 50 to 75 mm.

Localities. — Horse Race, Lily Pond, Field's orchard, Turners Falls, Moody's corner and South Hadley in Massachusetts, and Middletown, Connecticut.

Batrachopus dispar Lull

Lull 1904 A, p. 483, fig. 2. *B. deweyanus* (part).

Type specimen, Cat. No. 21/1, Amherst collection, on red shale from Lily Pond, Turners Falls, Mass. Other localities not ascertained.

Specific Characters. — Manus: Four digits impressing. Divarication of digits I and II, 26°; II and III, 68°; III and IV, 20°; I and IV, 122°. Length of foot, 30 mm.; distance between lateral tips, 28 mm.

Pes: Length of digit I, 46 mm.; II, 67 mm.; III, 72 mm.; IV, 62 mm.; entire foot 73 mm.; distance between lateral tips, 53 mm. Divarication of digits I and II, 18°; II and III, 20°; III and IV, 22°; I and IV, 60°. Length of step, 230 mm.

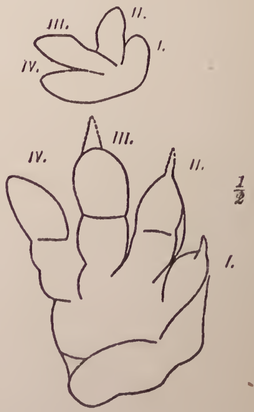

Fig. 33.—*Batrachopus dispar* One-half nat. size. After Lull.

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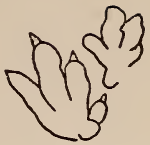
[1] Measurements, unless otherwise stated, are taken from the type specimens.

Batrachopus gracilis (E. Hitchcock)



Anisopus gracilis E. Hitchcock 1848, p. 228, pl. 16, figs. 3-4; 1858, p. 61, pl. 9, fig. 4; pl. 35, fig. 5; pl. 36, fig. 1; pl. 43, figs. 3-5; pl. 58, fig. 9.

Anisichnus gracilis C. H. Hitchcock 1889, p. 119.

Lull 1904 A, p. 484, fig. 3; 1904 C, p. 381, fig.

Type specimen, Cat. No. 42/3, Amherst collection. Type locality unrecorded.

Specific Characters. — Manus: Length of digit II, 12 mm.; III, 13 mm.; IV, 11 mm.; V, 4 mm. Divarication of digits I and II, 23°; II and III, 25°; III and IV, 44°; IV and V, 62°.

Pes: Length of digit I, 11 mm.; II, 21 mm.; III, 23 mm.; IV, 31 mm.; entire foot, 36 mm. Distance between lateral claws, 28 mm. Divarication of digits I and II, 23°; II and III, 20°; III and IV, 30°; I and IV, 73°.

Length of step, 209 mm.

Variations in digit divarication and as regards imprint of I and V of the manus.

Localities. — Horse Race, Field's orchard, Gill, Lily Pond, Turners Falls below dam, ferry above Turners Falls, ferry at Turners Falls, Mass.; Portland and Middlefield, Conn.

This species is also reported from New Jersey and Pennsylvania and is the one I would correlate with *Stegomus longipes*.

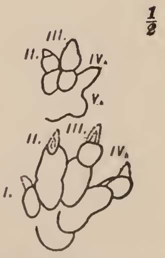


FIG. 34.— *Batrachopus gracilis*. One-half nat. size. After Lull.

Batrachopus gracilior (E. Hitchcock)

Anisopus gracilior E. Hitchcock 1863, p. 54; 1865, p. 6, pl. 1, fig. 3.

Anisichnus gracilior C. H. Hitchcock 1889, p. 119.

Lull 1904 A, p. 484.

Type, Cat. No. 46/3, Amherst collection, on reddish shale. Type locality unrecorded.

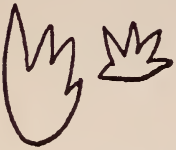


FIG. 35.—*Batrachopus gracilior*. Nat. size. After Hitchcock.

Specific Characters. — Manus: Length of digit I, 5 mm.; II, 8 mm.; III, 8 mm.; IV, 7 mm.; V, 5 mm.; entire foot, 8 mm. Divarication of digits I and II, 35°; II and III, 37°; III and IV, 11°; IV and V, 77°.

Pes: Length of digit I, 9 mm.; II, 12.5 mm.; III, 14 mm.; IV, 15 mm.; entire foot, 15 mm. Distance between lateral claws, 12 mm. Divarication of digits I and II, 14°; of II and III, 11°; of III and IV, 15.5°.

Length of step, 46 mm. Width of trackway, 50 mm. Ratio of foot to stride, 1 : 3. Distinguished from *B. gracilis* by the smaller size, shorter stride, and wider trackway. It is not a typical *Batrachopus,* and may find its real relationship with *Arachnichnus.*

Localities. — Horse Race, Montague, Turners Falls and Lily Pond, Mass.

Batrachopus bellus (E. Hitchcock)

Apatichnus bellus E. Hitchcock 1858, p. 101, pl. 17, fig. 6; pl. 35, fig. 8; pl. 45, fig. 6.

Lull 1904 A, p. 485.

Type, Cat. No. 26/21, Amherst collection, on red shale from Turners Falls, Mass.

Specific Characters.— Manus: Length of foot, 13 mm.; divarication of outer digits, 40°.

Pes: Length of digit I, 5 mm.; II, 10 to 18 mm.; III, 20 to 25 mm.; IV, 15 to 20 mm.; entire foot, 26 mm.

Length of step, 100 to 170 mm. Width of trackway, 63 mm. Ratio of foot to step averages 1 : 6.

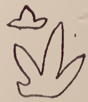


FIG. 36.—*Batrachopus bellus.* One-half nat. size. Original.

"This form is long of limb and strictly quadrupedal in gait, though the light impression of the manus is not always discernible. The latter character removes it from *Apatichnus,* and both characters would tend to ally it with *Batrachopus.* In size it lies between *B. gracilis* and *B. gracilior,* but the length of limb would place it nearer the former" (Lull).

Localities.— Turners Falls and Lily Pond? , Mass.

Suborder AËTOSAURIA?

Genus **Cheirotheroides** E. Hitchcock

E. Hitchcock 1858, p. 130.

Lull 1904 A, p. 485.

Generic Characters. — Quadrupedal; feet unequal in size; pes functionally tetradactyl, manus pentadactyl. The three inner digits of the pes generally terminate in rounded claws, the fourth does not. Limbs rather short, ratio of foot to step being 3 : 4.

Cheirotheroides pilulatus E. Hitchcock

E. Hitchcock 1858, p. 130, pl. 23, fig. 4; pl. 36, fig. 6; pl. 54, fig. 3.

Lull 1904 A, p. 485.

Type specimen, Cat. No. 34/44, Amherst collection, from Turners Falls, the only recorded locality.

Specific Characters. — Manus: Length of digit I, 4 mm.; II, 8 mm.; III, 9 mm.; IV, 6 mm.; V, 4 mm. Divarication of digits I and II, 57°; II and III, 60°; III and IV, 28°; IV and V, 20°.

Pes: Length of digit I, 10 mm.; II, 14 mm.; III, 18 mm.; IV, 18 mm.; entire foot, 22.5 mm. Distance between lateral tips, 14 mm. Divarication of digits I and II, 10°; II and III, 15°; III and IV, 15°.

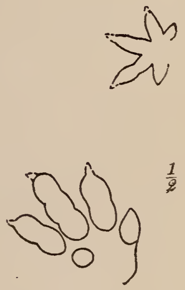


Fig. 37.— *Cheirotheroides pilulatus.* One-half nat. size. Original.

Length of step, 320 mm. Width of trackway, 570 mm.

This species is doubtfully placed under the Aëtosauria, though it resembles *Batrachopus gracilior* most closely, especially in short limbs and broad body, differing therefrom in the rounded, pellet-like character of the claws. It is an extremely rare species.

Specimen No. 2127, Yale collection, I have referred to this genus under which it may represent a new species. It is from the Towner quarries, Upper Middletown (Cromwell?), Conn.

Order **DINOSAURIA**

Suborder **THEROPODA**

Strictly bipedal, digitigrade forms, with a generally tetradactyl mesaxonic foot; hallux occasionally impressing, but generally rotated to the rear. Claws acuminate. Limbs moderately to very long, trackway narrow. Occasional tail trace.

In the genera which I have placed under this suborder the manus *never* impresses itself, and here are included tracks actually made by birds if any such there were.

I have added to the list one genus, *Otouphepus,* described since my former work, and the genus *Eubrontes* which was included under the Orthopoda in my previous list.

Family ANCHISAURIPODIDÆ.

Footprints of dinosaurs of the family Anchisauridæ Marsh.

Family Characters. — Bipedal, tetradactylous, hallux when impressing rotated to rear. Well marked phalangeal pads; anterior claws acuminate but not strongly raptorial. No caudal impression (Lull 1904 A, p. 486).

Genus **Anchisauripus** Lull

Eubrontes (in part) E. Hitchcock 1845, p. 23.

Brontozoum (in part) E. Hitchcock 1847, p. 50.

Lull 1904 A, p. 486.

Generic Characters. — Those of the family. The hallux evidently bore a well developed sub-functional grasping claw which only impressed when the rear of the foot was strongly pressed down as in stopping, or when walking on soft sediment.

Limbs of moderate length though naturally the stride varies with the gait.

These are the footprints of the dinosaurs *Anchisaurus* and *Ammosaurus*, the skeletons of which have been described above, and include a portion only of the species first described by Hitchcock under the generic name *Eubrontes* and later under that of *Brontozoum*. The remaining species of the genus *Eubrontes* are still included under that title (*vide infra* p. 195). The type species is *Anchisauripus sillimani* (*Eubrontes dananus, Brontozoum sillimanium*); the footprint of *Anchisaurus colurus*, Marsh.

Anchisauripus sillimani (E. Hitchcock)

Ornithoidichnites sillimani E. Hitchcock 1843, p. 256, pl. 11, fig. 2.

Eubrontes dananus E. Hitchcock 1845, p. 23 (in part).

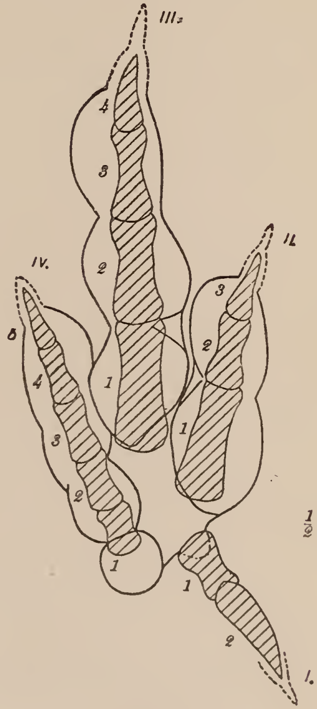


FIG. 38.—*Anchisauripus sillimani*. One-half nat. size. After Lull.

Brontozoum sillimanium E. Hitchcock 1847, p. 49; 1858, p. 68, pl. 12, fig. 3; pl. 33, figs. 4-5; pl. 43, fig. 6 (in part).

Anchisauripus dananus Lull 1904 A, pp. 487-488, fig. 4.

Specific Characters. — Pes: Length of digit I, 50 mm.; II, 77 mm.; III, 115 mm.; IV, 88 mm.; entire foot not including hallux, 153 mm, with hallux, 187 mm. Distance between lateral tips, 67 mm. Divarication of digits I and II, 139°; II and III, 11°; III and IV, 18°.

Length of step, 300 to 560 mm. Width of trackway, 115 mm.

Type specimen, Cat. No. 9/14, Amherst collection, from Middletown, Conn.

Localities. — This species is found in nearly all the upper horizon localities, such as Horse Race, Lily Pond, ferry above Turners Falls, ferry at Turners Falls, Field's orchard in Gill, Smith's Ferry, South Hadley, Moody's corner, stream near Pliny Moody's, and Chicopee Falls, Mass.; Wethersfield, Portland, Middletown, Middlefield (posterior shales), Conn.; Whitehall, N. J.; near Goldsboro, York county, and 1½ miles northeast of Trap, about 10 miles northwest of Valley Forge, Penn.

Anchisauripus hitchcocki Lull

Lull 1904 A, p. 488, fig. 5.

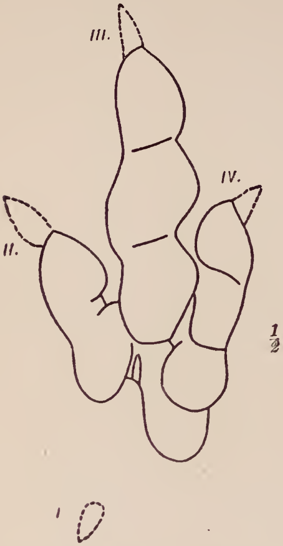


Fig. 39.—*Anchisauripus hitchcocki*. One-half nat. size. After Lull.

Type specimen, Cat. No. 56/1, Amherst collection, from the Lily Pond, Turners Falls, Mass., associated with *Anchisauripus minusculus*, and figured in E. Hitchcock 1865, pl. 16, fig. 1. Further localities not ascertained.

Specific Characters.—Pes: Length of digit II, 60 mm.; III, 88 mm.; IV, 75 mm.; foot exclusive of hallux, 119 mm., including the hallux, 140 mm. Distance between lateral tips, 67 mm. Divarication of digits I and II, 138°; II and III, 19°; III and IV, 33°.

Length of step unknown.

This footprint agrees with what one would be led to expect the pes of *Anchisaurus polyzelus* to be, judging from the relative sizes of the known part of the skeleton and that of *A. colurus.*

Anchisauripus tuberosus (E. Hitchcock)

Ornithichnites tuberosus E. Hitchcock 1836, p. 318, figs. 2, 5 (in part).

Ornithoidichnites tuberosus E. Hitchcock 1841, p. 486, pl. 37, fig. 20 (in part).

Eubrontes tuberosus E. Hitchcock 1845, p. 23.

Brontozoum loxonyx E. Hitchcock 1848, p. 172, pl. 2, figs. 1-2.

Brontozoum validum E. Hitchcock 1858, p. 67, pl. 12, fig. 2; pls. 38-43; pl. 57, fig. 3.

Lull 1904 A, p. 488, fig. 6.

Type specimen, Cat. No. 31/73, Amherst collection, on red shale from Turners Falls, Mass.

Specific Characters.— Pes: Length of digit II, 86 mm.; III, 128 mm.; IV, 120 mm.; foot exclusive of hallux, 168 mm., with hallux, ?195 mm. Divarication of digits I and II, ?135°; II and III, 14°; III and IV, 13°.

Length of step, 440 mm.

Other specimens than the type prove somewhat larger and yet are clearly referable to the species.

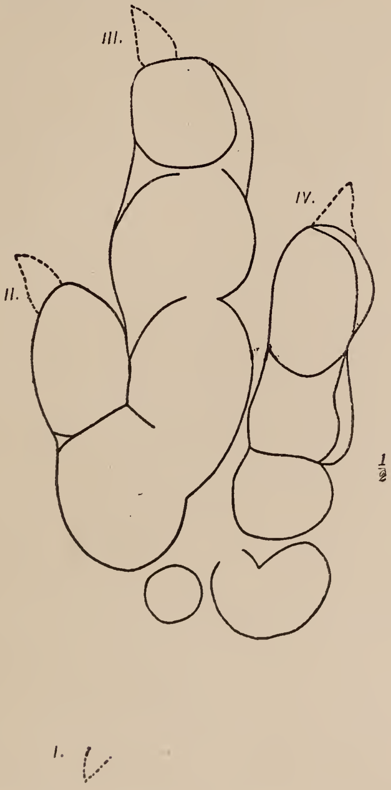


Fig. 40.—*Anchisauripus tuberosus.* One-half nat. size. After Lull.

"A very numerous and variable type, in size between *Anchisauripus sillimani* and *A. exsertus,* with no marked peculiarities other than size to distinguish it from either" (Lull). The type specimen unfortunately has been trimmed in such a way as to destroy the hallux impression if it existed, the presence of the hallux being unsuspected until demonstrated by Lull in 1904.

Localities. — Horse Race, Lily Pond, Turners Falls, Field's orchard in Gill, north side Mount Holyoke (anterior shales), east side Mount Tom, Smith's Ferry, South Hadley, Moody's corner, Mass.; and Wethersfield and Portland, Conn.

Anchisauripus exsertus (E. Hitchcock)

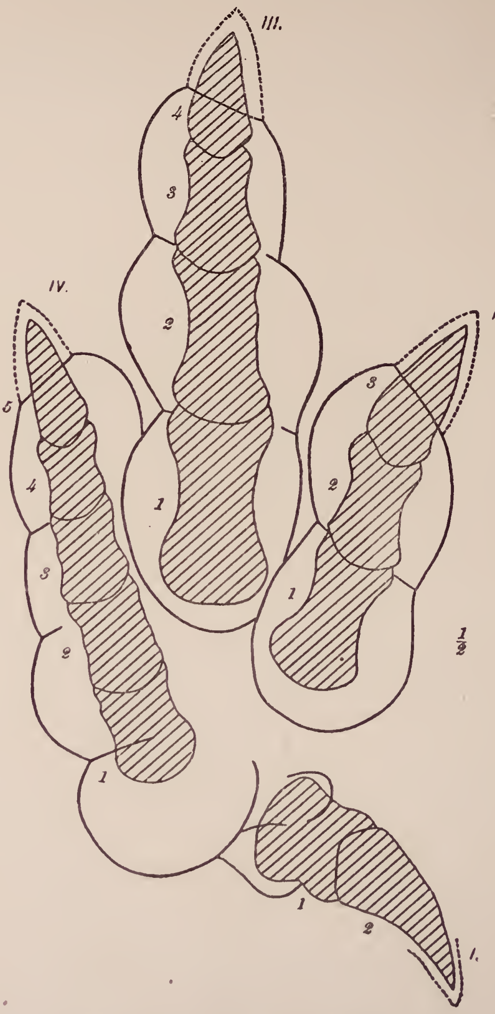


FIG 41.—*Anchisauripus exsertus*. One-half nat. size. After Lull.

Brontozoum exsertum E. Hitchcock 1858, p. 67, pl. 12, fig. 1; pl. 40, fig. 3.

Lull 1904 A, p. 489, fig. 7.

Type specimen, Cat. No. 16/6, Amherst collection, on gray micaceous sandstone from Smith's Ferry, Mass.

Specific Characters. — Pes: Based upon Cat. No. 54/1, Amherst collection (plesiotype). Length of digit I, 75 mm.; II, 117 mm.; III, 161 mm.; IV, 153 mm.; foot exclusive of hallux, 226 mm., including hallux, 265 mm. Divarication of digits I and II, 75°; II and III, 20°; III and IV, 20°.

Length of step in type No. 16/6, a somewhat larger specimen, 922 mm.

"The real distinction between this species and *A. tuberosus* seems to be one of size only, for the character which gives the name '*exsertus*,' that of the unusual projection of the middle toe beyond the lateral ones, is not always manifest" (Lull).

This species I have correlated with *Ammosaurus major.* The distribution, as will appear below, is geographically coextensive with the valley. In time it seems to date from the anterior shales, though the identification of this specimen is somewhat doubtful.

Localities. — Horse Race, Gill, Lily Pond, ferry above Turners Falls, ferry at Turners Falls, Field's orchard in Gill, ?north side Mount Holyoke (anterior shales), Mount Tom east, Smith's Ferry, Moody's corner, Chicopee Falls, Mass.; and Wethersfield, Portland, Middlefield (posterior shales), Conn.

Anchisauripus minusculus (E. Hitchcock)

Brontozoum minusculum E. Hitchcock 1858, p. 65, pl. 11, fig. 1; pl. 40, fig. 2; pl. 41, fig. 1; pl. 42, fig. 3; pl. 57, fig. 2.

Lull 1904 A, p. 490, fig. 8.

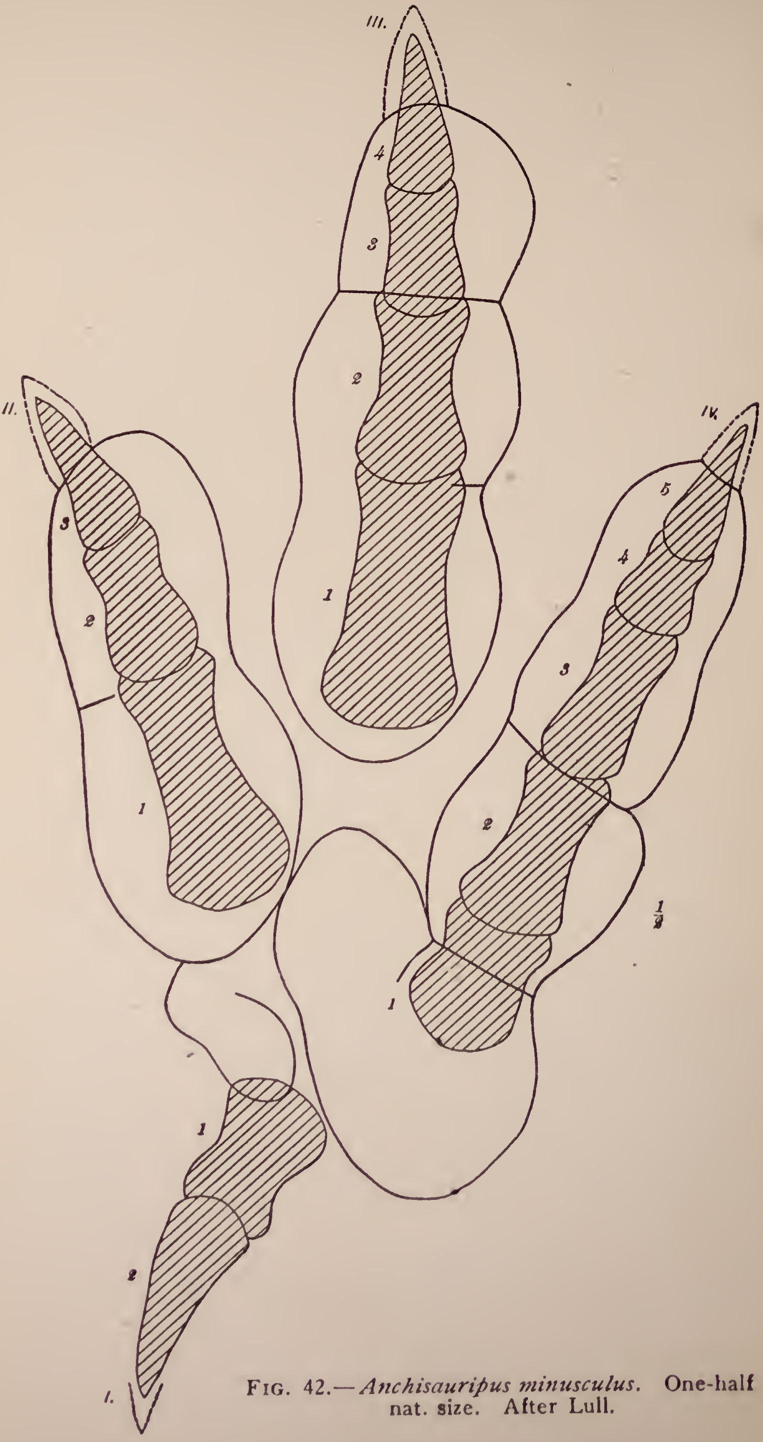
Type specimen, Cat. No. 16/1, Amherst collection, on fine red shale from the Lily Pond at Turners Falls, Mass.

Specific Characters. — Pes: Length of digit I, 100 mm.; II, 158 mm.; III, 192 mm.; IV, 223 mm.; foot exclusive of hallux, 307 mm., including hallux, 374 mm. Divarication of digits I and II, 140°; II and III, 24°; III and IV, 24.5°.

Length of step 1,000 mm.

"This magnificent form is the largest of the genus, and indicates an animal about twice the size of *Anchisaurus colurus,* which would give it a length of about fourteen feet" (Lull).

Localities. — Horse Race, Gill, Lily Pond, ferry at Turners Falls, Turners Falls, Smiths Ferry, South Hadley and Moody's corner in Mass.; Wethersfield, Conn.; and Whitehall, N. J.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I.

FIG. 42.—*Anchisauripus minusculus.* One-half nat. size. After Lull.

Anchisauripus parallelus (E. Hitchcock)

Grallator parallelus E. Hitchcock 1865, p. 7, pl. 5, fig. 1.

Lull 1904 A, pp. 490-491, fig. 9.

Type specimen, Cat. No. 54/8, Amherst collection, on red sandstone from Gill, Mass.

Specific Characters.—Pes: Length of digit I, 67 mm.; II, 79 mm.; III, 120 mm.; IV, exclusive of "heel" pad, 90 mm.; foot exclusive of hallux, 165 mm., including hallux, 210 mm. Divarication of digits I and II, 141°; II and III, 12°, III and IV, 6.5°.

Length of step, 260 mm.

This form is removed from *Grallator* because of the shortness of step and relatively wide trackway and also by the presence of the hallux impression. Its nearest ally in point of size is *A. sillimani;* but the nearly parallel axes of the toes, especially the third and fourth, the relative narrowness of digit IV, and the presence of three heel pads in addition to the four normally found in that toe, separate the two species.

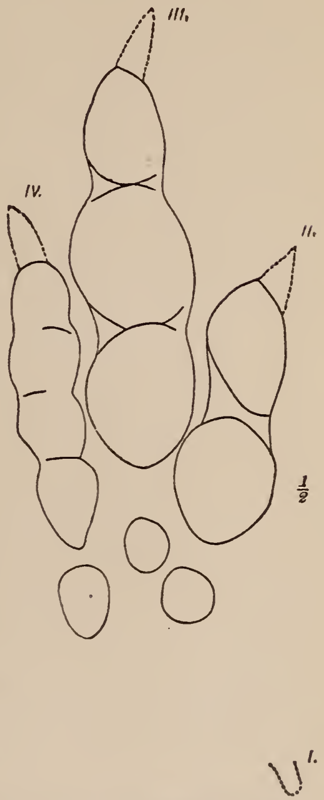


FIG. 43.—*Anchisauripus parallelus.* One-half nat. size. After Lull.

Localities.—Horse Race, Lily Pond, Gill, Turners Falls, Field's orchard, South Hadley, Moody's corner, Mass.; Whitehall, N. J.

Anchisauripus tuberatus (E. Hitchcock)

See *Eubrontes tuberatus* (p. 199).

Family OTOUPHEPODIDÆ

Genus **Otouphepus** Cushman

Cushman 1904, p. 154.

Cushman's generic definition is as follows:

"Footprint tridactylous, digits decidedly pachydactylous, connected by a web, incised between the digits. Impressions of the joints of the digits very indistinctly shown. Digits terminated by fairly sharp claws, the expansions however extending beyond as the foot is placed flat upon its under surface. . . . .

"As the foot is placed flat, the web on the inner margin is spread out and the scallops distinctly seen. They are very similar to certain of the reptiles of the present time in this respect.

"Although such a footprint cannot be placed in any of the present genera as they are defined by Hitchcock, it is very probable that it represents an animal of the type of *Eubrontes dananus* E. Hitch. (*Brontozoum sillimanium* E. Hitch.) [*Anchisauripus sillimani*]. However, in perfect specimens of that species in the same sort of matrix where a distinct outline is shown, there are no such traces of a web. There are slight expansions, but they are of a different nature. The measurements and number of joints are very similar; but so they are in *Plesiornis mirabilis* of Hitchcock [probably identical with *Anchisauripus tuberosus*] which is nearer *E. dananus* than the present form under discussion. The joints of the phalanges, the turning aside of the claws, and the general skeletal shape would put the animal which made the present track in group II. of Hitchcock, p. 63 — although they were doubtless Dinosaurs and not 'thick-toed birds,' as he terms them."

This genus, though founded upon a single specimen, seems valid, especially in view of the fact that a second, though much smaller, track appears in the Yale collection (Cat. No. 2059) from the same locality, which is doubtless referable to it. I believe, however, that the name is founded on a misconception, as the track is certainly not that of a giant (Ὦτος) among dinosaurs, and the web (ὑφή) also seems to me very doubtful. *Otozoum moodii* has been described as having a web-like flange extending around and beyond the foot. This, which will be discussed at greater length under that species, proves to be only a wave of displaced mud, which may be seen also in specimens of *Anchisauripus sillimani* from Portland in association with *Otozoum* which are preserved in the Wesleyan museum and at Yale. This, in the case of *Anchisauripus,* heightens still more its resemblance to *Otouphepus.* The foot is rather a compact cursorial type, which, like that of the ostrich, *Struthio,* may prove a semi-desert adaptation rather than the semi-aquatic life a web would imply.

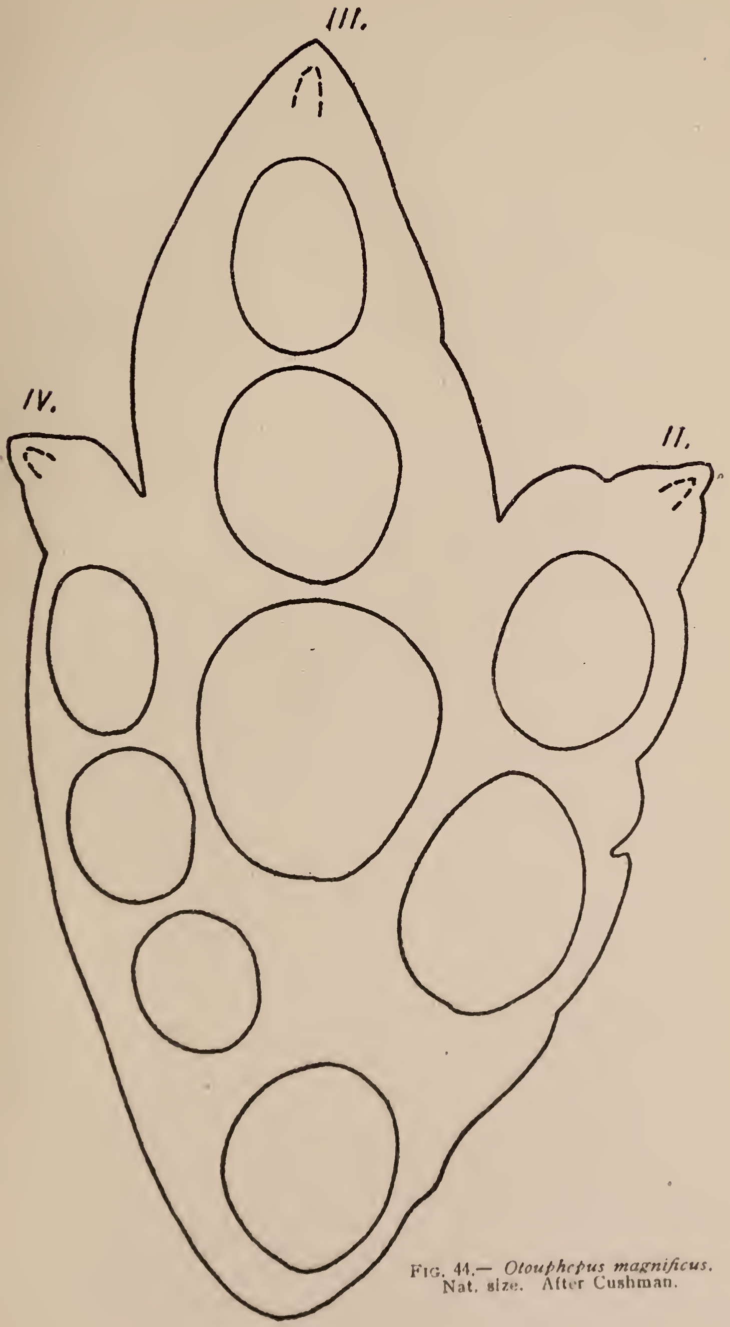


FIG. 44.— *Otouphepus magnificus.* Nat. size. After Cushman.

Otouphepus magnificus Cushman

Cushman 1904, p. 154, pl. vi.

Type specimen, Cat. No. 12,857, Boston Society of Natural History, from Gill, Mass., the only recorded locality.

Specific Characters. — Pes: Length of digit II, 83 mm.; III, 114 mm.; IV, 114 mm.; entire foot, 165 mm. Distance between lateral tips, 89 mm. Divarication of digits II and III, 22°; III and IV, 17° approximately.

Length of step not known.

Otouphepus minor, sp. nov.

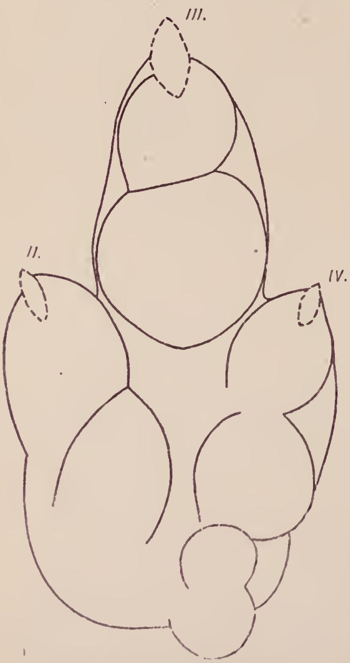


FIG. 45.— *Otouphepus minor.* Nat. size. Original.

Type specimen, Cat. No. 2059, Yale collection, from Gill, Mass. A unique specimen.

Specific Characters. — Pes: Length of digit II, 47 mm.; III, 56 mm.; IV, 52 mm.; entire foot, 85 mm. Distance between lateral claws, 39 mm. Divarication of digits II and III, 20°; III and IV, 21°; II and IV, 40°.

Length of stride unknown.

In this specimen the phalangeal impressions are for the most part extremely obscure, but the displacement of the mud shows itself especially on either side of the most deeply impressed middle digit, the surface of the shale being thrown into innumerable minute parallel wrinkles. The web-like wave embraces the claw impressions as in *O. magnificus.* The principal diagnostic distinction between the species is that of size, another being the rather less projection of the fourth digit in *minor* as compared with that in *magnificus.*

In size the present species compares with *Grallator cursorius,* being a little larger. It is about half that of *Anchisauripus tuberosus,* and not far from the dimensions of the foot of *Anchisaurus solus* among the osseous species.

Family GIGANDIPODIDÆ

Lull 1904 A, p. 492.

Family Characters. — "Large bipedal forms. Tetradactyl, hallux half rotated, incumbent. Foot flatly digitigrade. Claws acuminate. No manus impression. Caudal trace." Genera *Gigandipus* and *Hyphepus.*

Genus **Gigandipus** E. Hitchcock

E. Hitchcock 1855, p. 417 (no description); 1856, p. 97.

Gigantitherium E. Hitchcock 1858, p. 93.

Lull 1904 A, p. 492.

Generic Characters. — Those of the family, the most readily recognized being the small hallux which lies at right angles to digit II, instead of being rotated far to the rear as in *Anchisauripus.* In the type specimen the hallux impresses the mud for its entire length, though here the whole track is deep, the toe evidently arising much lower on the leg than in *Anchisauripus.* The pads of the heels are also well developed in contrast to *Anchisauripus* and, in the type, the claw of digit II is especially strong and acuminate. The tail trace when present is sinuous and continuous. In Cat. No. 2091, Yale Museum, no tail trace is visible, and superficially the track resembles that of *Eubrontes giganteus* except for the position of the hallux. The two species are doubtless sometimes confused.

The form of the foot of *Gigandipus* agrees very closely with that of *Allosaurus fragilis* from the Morrison, but the former, while vying with *Eubrontes giganteus* as the most majestic of Newark dinosaurs, falls far short of the dimensions of the 34-foot *Allosaurus* (see below).

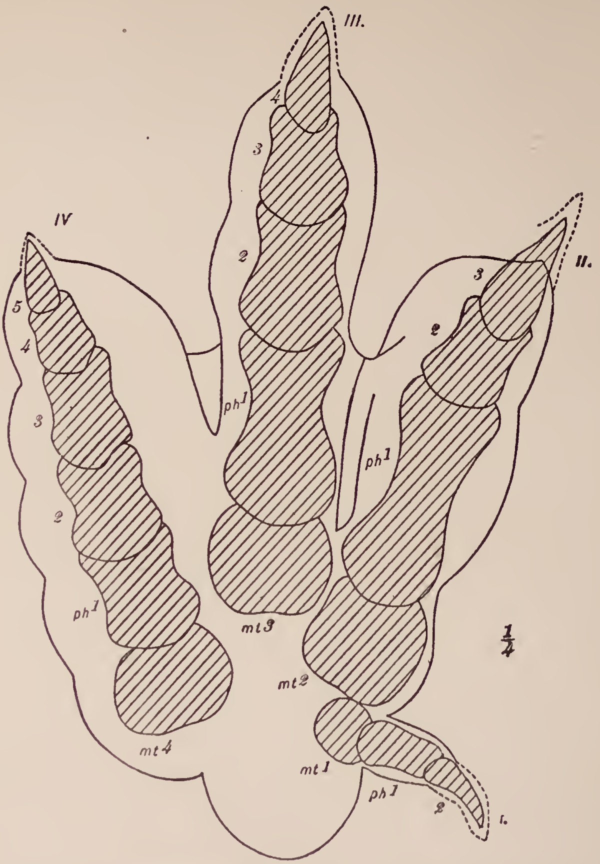
Gigandipus caudatus E. Hitchcock

E. Hitchcock 1855, p. 417 (no description); 1856, p. 97, text fig.

Gigantitherium caudatum E. Hitchcock 1858, p. 93, pl. 16, figs. 1-2; pl. 44, fig. 4.

Lull 1904 A, pp. 492-493, fig. 11; 1904 B, fig. on p. 141.

Type specimens, Cat. Nos. 9/9 and 9/10, Amherst collection, on reddish shale from the Lily Pond, Turners Falls, Mass. There is no other recorded locality, the species being extremely rare,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ph1
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FIG. 46.— *Gigandipus caudatus*. One-fourth nat. size. After Lull.

unless other specimens have been wrongly identified as *Eubrontes giganteus*.

Specific Characters. — Pes: Length of digit I, 80 mm.; II, to metatarsal pad, 215 mm., including the pad, 280 mm.; III, to metatarsal pad, 275 mm.; IV, to metatarsal pad, 290 mm., including pad, 343 mm.; entire foot, 445 mm. Distance between lateral toes, 285 mm. Divarication of digits I and II, 98°, II and III, 22°; III and IV, 30°.

Length of step, 1,020 mm. Width of trackway, 305 mm.

Comparing the relative proportions of the foot impressions of this species, 445 mm., and those of *Allosaurus*, 720 mm., would give to *Gigandipus* a length of approximately 27 feet, provided the ratio of entire bodily length to that of the track remained the same.

Genus **Hyphepus** E. Hitchcock

E. Hitchcock 1858, pp. 97, 180.

Lull 1904 A, p. 493.

Generic Characters. — Bipedal, tetradactylous, hallux incumbent, curved sharply backward. Phalangeal pads obscurely defined; anterior digits apparently clawless.

The apparently webbed condition which gave rise to the generic name (" ὑφή, a web, and πούς, a foot; the web-footed animal," Hitchcock) may be, as in the case of *Otozoum* (*vide infra* p. 222), merely the wave of mud pressed out from beneath the track. I have little faith in a web-footed animal among the terrestrial vertebrates of the Connecticut valley.

This form resembles *Gigandipus* except for its much smaller size and apparently the clawless condition of the impression of the anterior digits. The actual claws may, however, have been partially retracted if that were possible. It is therefore placed in the family Gigandipodidæ, though the relationship may not have been very close.

Hyphepus fieldi E. Hitchcock

E. Hitchcock 1858, pp. 97, 180, pl. 17, fig. 2; pl. 35, fig. 11; pl. 41, fig. 2; pl. 42, fig. 2.

Lull 1904 A, pp. 493-494.

Type, Cat. No. 1/3, Amherst collection, on micaceous shale, from Turners Falls, Mass.

Specific Characters. — Pes: Length of digit I, 26 mm.; II, 77 mm.; III, 78 mm.; IV, 83 mm.; entire foot, 128 mm. Distance between lateral toes, 71 mm. Divarication of digits I and II, 118 °; II and III, 23°; III and IV, 28°; II and IV, 50°.

Length of step, 153 mm. Width of trackway, 135 mm.

Localities. — Lily Pond and Turners Falls, Mass.

Family EUBRONTIDÆ.

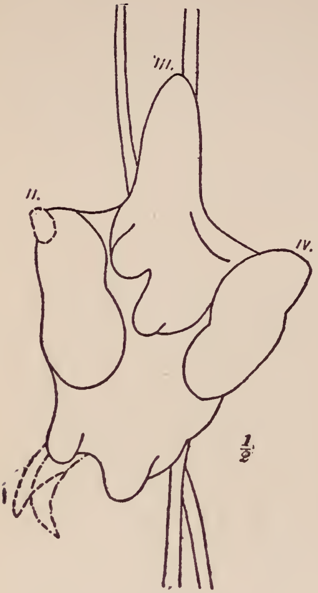

Fig. 47.—*Hyphepus fieldi.* One-half nat. size. Original. Composite of two impressions showing variation in position of hallux claw and tail trace.

Lull 1904 A, p. 510.

Family Characters.—Large bipedal forms; claws acuminate to blunted; digits broad with distinct phalangeal pads. Foot functionally tridactyl as hallux claw never impresses. Caudal trace absent. Distinguished from *Anchisauripus* by the generally larger size and broad clumsy feet, and the fact that the claws are generally blunted, though this character is variable within the same species or even upon the same track (see figs. 50, 52). The apparent total absence (with one possible exception) of a hallux impression distinguishes *Eubrontes* both from *Anchisauripus* and *Gigandipus.*

In my former work (1904 A) I placed *Eubrontes* under the plant-feeding orthopod dinosaurs because of the "lack of a grasping hallux, the heavy, slow-moving tread, and the blunter claws [which] are surely not carnivorous characters, but seem to point rather to an herbivorous habit of life" (p. 544). However, I go on to say, "It may be that, instead of being orthopod or predentate dinosaurs, the Eubrontes represent another group of aberrant carnivora, which, like the condor (*Sarcorhamphus gryphus*), because of carrion-feeding habits, did not retain the raptorial claws of its predaceous allies."

I am now inclined to think that the only reasonably sure indication that footprints were made by an herbivorous dinosaur lies in the impression of the manus, unless, as in the *Iguanodon* tracks of Belgium and England (Dollo), the footprints are actually and exclusively associated with remains of dinosaurs of that group.

Genus **Eubrontes** E. Hitchcock

E. Hitchcock 1845, p. 23.

Brontozoum E. Hitchcock 1847, p. 50; 1848, p. 169; 1858, p. 63.

Lull 1904 A, p. 510.

Generic Characters.— Those of the family.

Eubrontes giganteus E. Hitchcock

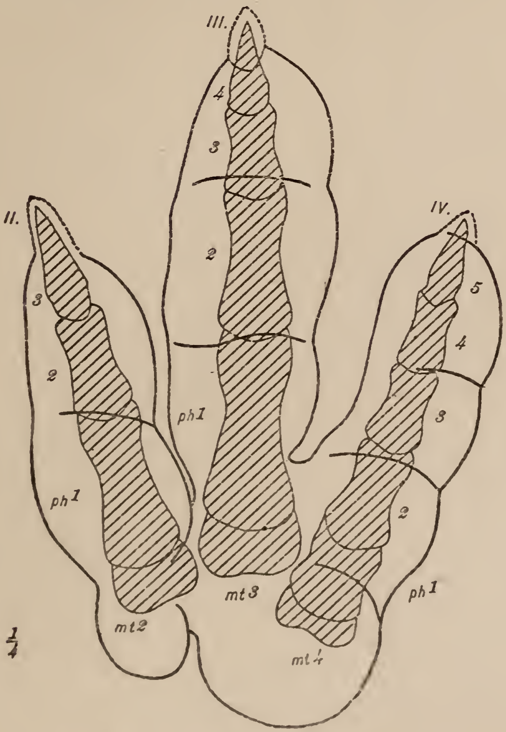

Fig. 48.— *Eubrontes giganteus.* One-fourth nat. size. After Lull.

Ornithichnites giganteus E. Hitchcock 1836, p. 317, figs. 1, 21.

Ornithoidichnites giganteus E. Hitchcock 1841, p. 484, pl. 36, fig. 18.

E. Hitchcock 1845, p. 23.

Brontozoum giganteum E. Hitchcock 1847, p. 57; 1848, p. 169, pl. 1, fig. 1; 1858, p. 64, pl. 33, figs. 1-3; pl. 41, fig. 1; pl. 53, fig. 7; pl. 57, fig. 1.

Recharacterized by C. H. Hitchcock in E. Hitchcock 1865, p. 23, pl. 10, fig. 1.

Lull 1904 A, pp. 510-511, fig. 31.

Type, Cat. No. 45/8, Amherst collection, locality unrecorded. My figure here reproduced is from Cat. No. 45/1 in the same collection, which becomes therefore a plesiotype.

Specific Characters. — Pes: Length of digit II, 200 mm.; III, 260 mm.; IV, 285 mm.; entire foot, 370 mm. Distance between lateral claws, 225 mm. Divarication of digits II and III, 18°; III and IV, 20°.

Length of step, 1,090 to 1,170 mm.

This species is, with the exception of *E. approximatus, Gigandipus caudatus,* and possibly *Otozoum moodii,* the largest of all Newark dinosaurs. The track would indicate an animal at least twenty feet in length and of massive build.

Localities. — Horse Race, Lily Pond, Turners Falls, north bank below Turners Falls, Mount Tom west (anterior shales), Smiths Ferry and ?Holyoke, Mass.; Wethersfield Cove, Wethersfield, Portland and Middlefield (posterior shales), Conn.; Whitehall, N. J.

This species is one of the earliest recorded in geologic time in the Connecticut valley, as the locality west of Mount Tom lies beneath the main trap sheet and is therefore in the anterior shales.

Eubrontes approximatus (C. H. Hitchcock)

Brontozoum approximatum C. H. Hitchcock in E. Hitchcock 1865, p. 24, pl. 10, fig. 2.

Lull 1904 A, pp. 511-512, fig. 32.

Type, Cat. No. 54/10, Amherst collection, on gray shale from Turners Falls, Mass.

Specific Characters. — Pes: Length of digit II, 192 to 153 mm.; III, 274 to 230 mm.; IV, 308 to 295 mm.; entire foot, 408 to 381 mm. Divarication of digits II and III, 15° to 30°; III and IV, 13° to 24°. In the above measurements the second in each case is from the type, Amherst collection, Cat. No. 54/10; and the first from an exceptionally large though otherwise typical individual, the one figured by Lull (fig. 49), Amherst collection, Cat. No. 32/51, which is therefore a plesiotype.

Length of step (from Cat. No. 8/1, Amherst collection), 910 to 1,080 mm.

This form is very near *E. giganteus*, being distinguished therefrom mainly by its slenderer proportions, the digits averaging 45 to 75 mm. in width in *approximatus* and 80 to 100 mm. in *giganteus*. The other distinguishing feature mentioned by C. H Hitchcock, that of the greater divarication of the toes, is not always apparent.

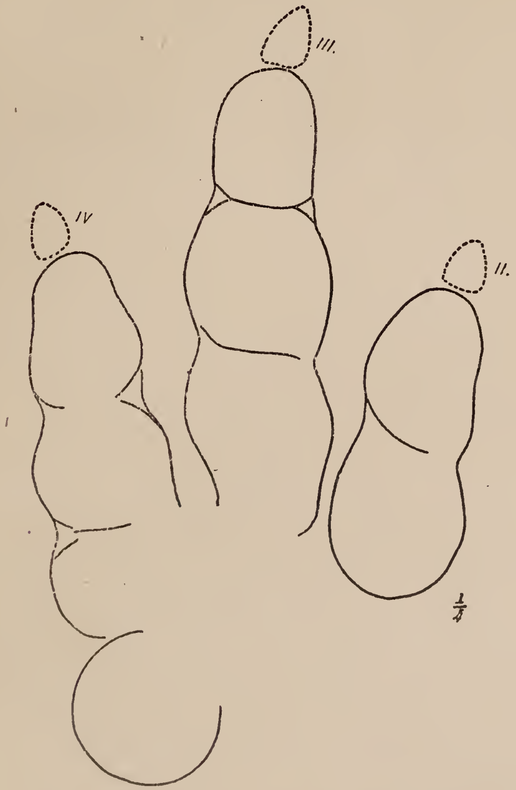

FIG. 49.—*Eubrontes approximatus*. One-fourth nat. size. After Lull.

Eubrontes divaricatus (E. Hitchcock)

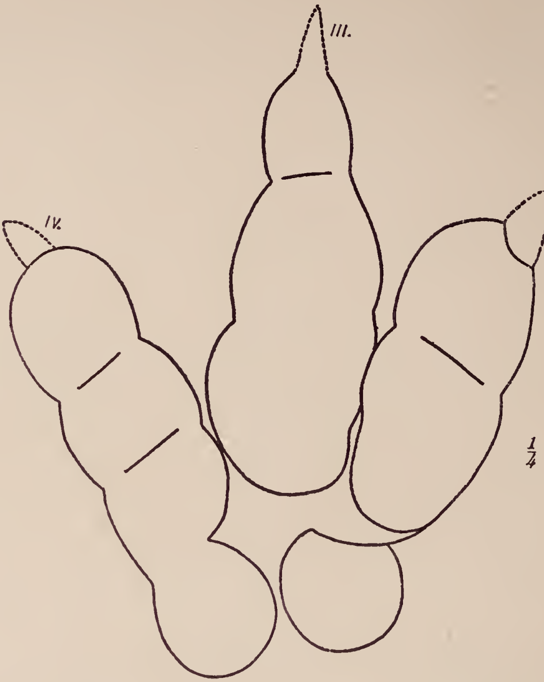

FIG. 50.—*Eubrontes divaricatus.* One-fourth nat. size. After Lull.

Brontozoum divaricatum E. Hitchcock 1865, p. 7, pl. 4, fig. 1. Lull 1904 A, p. 512, fig. 33.

Type specimen, Cat. No. 58/1, Amherst collection, on hard shale. Locality unrecorded.

Specific Characters. — Pes: Length of digit II, 193 mm.; III, 243 mm.; IV, 262 mm.; entire foot, 340 to 360 mm. Divarication of digits II and III, 20°; III and IV, 35° to 50°.

Length of step, 1,040 to 1,190 mm. This species is readily distinguished, apart from size, by the decided divarication of the outer toe.

Localities. — Horse Race, Lily Pond, Turners Falls, South Hadley, Mass.; Wethersfield, Conn.; Whitehall, N. J.

Eubrontes platypus Lull

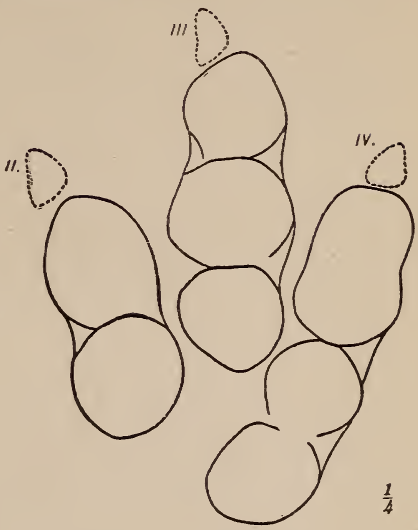

FIG. 51.—*Eubrontes platypus*. One-fourth nat. size. After Lull.

Amblonyx giganteus E. Hitchcock 1858, p. 71, pl. 13, fig. 1; pl. 38, figs. 1-2; pl. 57, fig. 5.

Lull 1904 A, pp. 512-513, fig. 34.

Type, Cat. No. 13/4, Amherst collection, on red shale from Turners Falls, which is the only known locality for this rare species.

Specific Characters.—Pes: Length of digit II, 157 mm.; III, 190 mm.; IV, 215 mm.; entire foot, 267 mm. Distance between lateral claws, 190 mm. Divarication of digits II and III, 12°; III and IV, 22°.

Length of step, 1,135 mm; very long limbed.

The name *platypus* was substituted for *giganteus* as the latter was preoccupied within the genus.

Eubrontes tuberatus (E. Hitchcock)

Brontozoum tuberatum E. Hitchcock 1858, p. 66, pl. 11, fig. 2; pl. 52, fig. 7.

Anchisauripus tuberatus Lull 1904 A, p. 491, fig. 10.

Type, Cat. No. 27/17, Amherst collection, on red shale from Turners Falls, Mass.

Specific Characters.— Pes: Length of digit II, 140 mm.; III, 172 mm.; IV, 107 mm.; entire foot, 249 mm. Distance between lateral claws, 152 mm. Divarication of digits II and III, 17°; III and IV, 8°.

Length of step unknown.

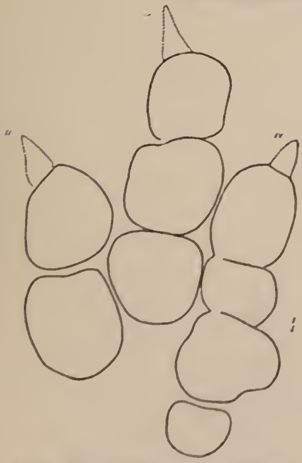

FIG. 52.—*Eubrontes tuberatus*. One-fourth nat. size. After Lull.

This species resembles the foregoing most nearly as regards size, but the phalangeal pads of the middle and outer digits are narrower and the claws more acuminate.

Localities. — Field's orchard in Gill, ?Lily Pond, Turners Falls, Mass.

Family GRALLATORIDÆ

Lull 1904 A, p. 494.

Family Characters. — Typically small, bipedal forms; footprints tridactyl, limbs very long; no manus nor caudal impressions. Genera: *Grallator, Stenonyx.*

Genus **Grallator** E. Hitchcock

E. Hitchcock 1858, p. 72.

Generic Characters. — Those of the family; with small compact feet having distinct phalangeal pads and moderately developed acuminate claws.

Distinguished from *Anchisauripus,* which it most closely resembles, by length of limb, general smallness of track, and absence of hallux.

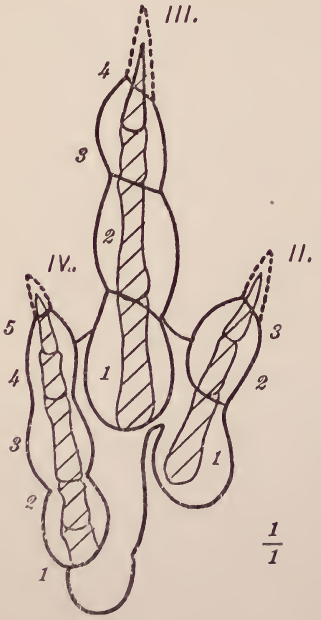

Fig. 53.—*Grallator cursorius.* Nat. size. After Lull.

Grallator cursorius E. Hitchcock

E. Hitchcock 1858, p. 72, pl. 13, fig. 3; pl. 58, fig. 4.

Lull 1904 A, p. 494, figs. 12-13.

Type specimen, Cat. No. 4/1, Amherst collection, in high relief on coarse sandstone, associated with *Anchisauripus sillimani* and the giant *Otozoum moodii* from Moody's corner, South Hadley, Mass.

Specific Characters. — Pes: Length of digit II, 35 mm.; III, 55 mm.; IV, 45 mm.; entire foot, 79 mm. Distance between lateral claws, 31 mm. Divarication of digits II and III, 14°; III and IV, 12°; II and IV, 26°.

Length of step, 610 mm. Width of trackway, 50 mm. Ratio of foot to step about 1 : 8.

Localities. — Lily Pond, ferry above Turners Falls, ferry at Turners Falls, Turners Falls, Field's orchard at Gill, Moody's corner, and South Hadley, Mass.; Wethersfield, Portland, ?Middletown and Middlefield (posterior shales), Conn.; Milford and Whitehall, N. J.

This is the species which corresponds with the compsognathoid dinosaur *Podokesaurus holyokensis* Talbot (*vide supra* p. 168) in form and proportions, horizon and locality.

Grallator tenuis E. Hitchcock

E. Hitchcock 1858, p. 73, pl. 13, fig. 4; pl. 53, fig. 5.

Lull 1904 A, p. 495, fig. 14.

Type specimens, Cat. Nos. 12/3 and 12/4, counterparts, Amherst collection, on red shale from Turners Falls, Mass., in close proximity to the trap.

Specific Characters. — Pes: Length of digit II, 30 mm.; III, 49 mm.; IV, 45 mm.; entire foot, 73 mm. Distance between lateral claws, 37 mm. Divarication of digits II and III, 15° to 25°; III and IV, 25° to 28°; II and IV, 40° to 45°.

Length of step, 195 mm. Width of trackway, 63 mm.

"The chief distinctions between this form and *G. cursorius* are the shorter stride and greater divarication of the toes of the present species. Both of these are variable quantities, and future research may prove the species to be synonymous, in which case *G. cursorius* would have priority" (Lull).

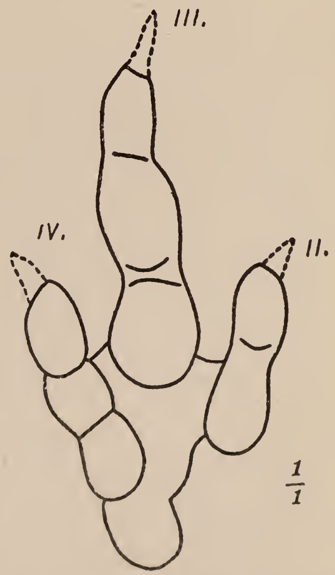

FIG. 54.— *Grallator tenuis.* Nat. size. After Lull.

I find upon studying the Yale material that I am rarely sure of the identification of tracks referable to one or the other of these species, especially when an isolated footprint is before me; on the other hand *G. tenuis* is the only track I know of which corresponds at all with the foot and length of limb of the dinosaur *Anchisaurus solus* Marsh (*vide supra* p. 148), which is not a compsognathoid form. It shows the futility of naming or classifying footprints upon assumed characters other than those actually manifest in the impressions themselves.

Localities. — Turners Falls, South Hadley, stream near Pliny Moody's in South Hadley, Mass.; Wethersfield and Portland, Conn.

Grallator gracilis C. H. Hitchcock

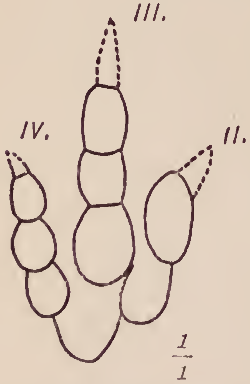

FIG. 55.— *Grallator gracilis.* Nat. size. After Lull.

C. H. Hitchcock in E. Hitchcock 1865, p. 8, pl. 9, fig. 7.

Lull 1904 A, p. 496, fig. 17.

Type, Cat. No. 17/2, Amherst collection, on red shale from Turners Falls, Mass. Plesiotype, figured by Lull, Cat. No. 23/8, also from Turners Falls.

Specific Characters. — Pes: Length of digit II, 26 mm.; III, 35 mm.; IV, 30 mm.; entire foot, 45 mm. Distance between lateral claws, 27 mm. Divarication of digits II and III, 22° to 23°; III and IV, 14° to 16°; II and IV, 35° to 40°.

Length of step, 315 mm.

One of the most diminutive of dinosaurs, one specimen of which seems to show a tail trace, the only recorded instance within the genus.

Localities. — Ferry above Turners Falls, ferry at Turners Falls, Turners Falls, ?Field's orchard in Gill, Mass.; Portland, Conn.; Milford, N. J.

Grallator cuneatus E. Hitchcock

E. Hitchcock 1858, p. 74, pl. 13, fig. 6; pl. 39, figs. 1, 3; pl. 41, figs. 1-2.

Lull 1904 A, p. 495, fig. 15.

Type, Cat. No. 25/1, Amherst collection, on red shale from the Lily Pond, Turners Falls, Mass. Plesiotype, figured by Lull, Amherst collection, Cat. No. 17/1, from Turners Falls.

Specific Characters. — Pes: Length of digit II, 63 mm.; III, 81 mm.; IV, 74 mm.; entire foot, 125 mm. Distance between lateral claws, 80 mm. Divarication of digits II and III, 23°; III and IV, 23°; II and IV, 46°.

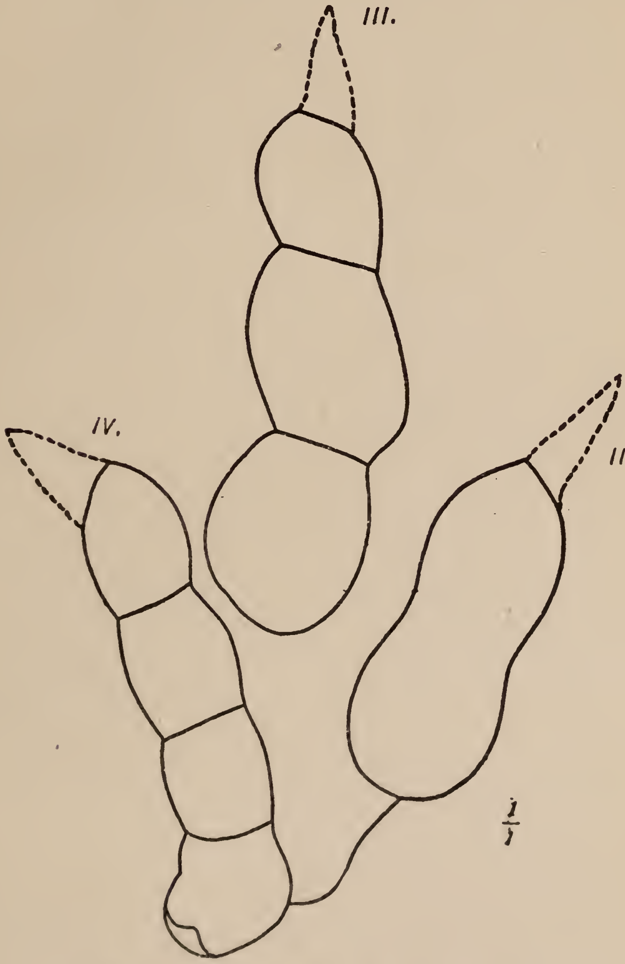

FIG. 56.—*Grallator cuneatus.* Nat. size.
After Lull.

Length of step, 460 to 550 mm. Width of trackway, 90 mm.

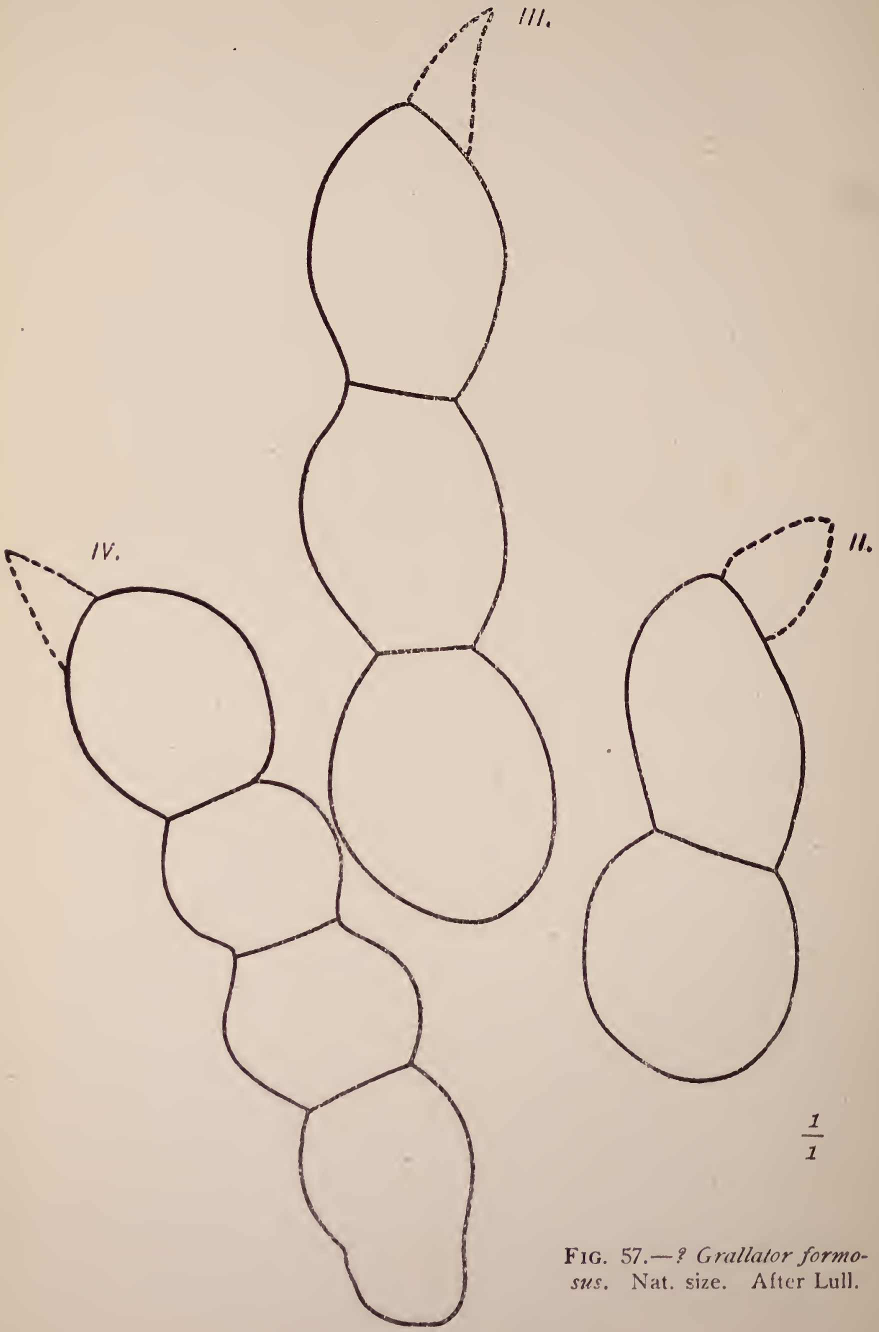

FIG. 57.—? *Grallator formosus.* Nat. size. After Lull.

This form, though large, is a true *Grallator,* quite similar in size to *Anchisauripus sillimani,* but distinguished from the latter by the greater projection of the middle toe, the lack of hallux, and the generally cuneiform shape of the foot, which is heightened by the bending outward of the lateral claws.

Localities. — Horse Race, Lily Pond, ferry above Turners Falls, Turners Falls, Field's orchard at Gill, Smiths Ferry, South Hadley, Chicopee Falls, Mass.; Wethersfield Cove, Wethersfield, Portland, Conn.; Milford, N. J. A very wide-spread species.

? **Grallator formosus** E. Hitchcock

E. Hitchcock 1858, p. 75, text fig. 1 on p. 77.

Lull 1904 A, p. 496, fig. 16.

Type specimen, Cat. No. 3/1, Amherst collection, from Moody's corner, South Hadley, associated with *Otozoum moodii.*

Specific Characters. — Pes: Length of digit II, 75 mm.; III, 118 mm.; IV, 114 mm.; entire foot, 172 mm. Distance between lateral claws, 110 mm. Divarication of digits II and III, 11.5°; III and IV, 21.5°; II and IV, 33°

Length of step, 655 mm.

A very large *Grallator,* but the stride is proportionately long and the hallux unknown.

Localities. — Lily Pond, Turners Falls, Field's orchard, Smith's Ferry, Moody's corner and stream near Pliny Moody's in South Hadley, Chicopee Falls, Mass.; Wethersfield, Conn.; Whitehall, N. J.

Genus **Stenonyx** Lull

Leptonyx E. Hitchcock 1865, p. 8 (name preoccupied).

Lull 1904 A, p. 498.

Generic Characters. — Bipedal, tridactyl, digitigrade track, very minute. Thick toes, long slender claws, and distinct phalangeal pads. Stride fairly short. No tail trace.

Stenonyx lateralis (E. Hitchcock)

Leptonyx lateralis E. Hitchcock 1865, p. 8, pl. 5, fig. 3.

Lull 1904 A, p. 498.

Type, Cat. No. 47/40, Amherst collection, from Turners Falls, Mass.

Specific Characters. — Pes: Length of digit II, 15 mm.; III, 21 mm.; IV, 21 mm.; entire foot,

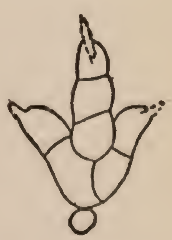

FIG. 58.— *Stenonyx lateralis.* Nat. size. Original.

30 mm. Distance between lateral claws, 21 mm. Divarication of digits II and III, 32°; III and IV, 28°; II and IV, 60°.

Length of step (from Cat. No. 2049, Yale collection), 70 mm.

This species seems to approach most nearly to *Grallator gracilis,* but is much smaller, and has more slender claws arising from the median side of digits II and III and from the outside of digit IV, hence the specific name. If these footprints were made by a dinosaur of the relative proportions of *Compsognathus longipes,* its length would be about fifteen inches; truly a "terrible lizard."

Localities. — Ferry above Turners Falls, Turners Falls, Mass.

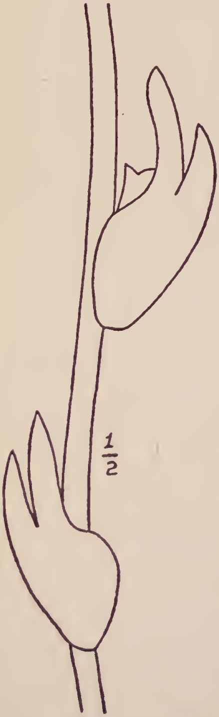

FIG. 59.—*Selenichnus falcatus.* One-half nat. size. Original.

Family SELENICHNIDÆ

Family Characters. — Bipedal, tridactylous. Inner toe rarely distinct. Tracks nearly in line without pads or claws. A generally continuous caudal trace, but slightly sinuous. Genus *Selenichnus.*

Genus **Selenichnus** E. Hitchcock

E. Hitchcock 1858, p. 133.
Lull 1904 A, p. 498.

Generic Characters.— Those of the family.

Selenichnus falcatus E. Hitchcock

E. Hitchcock 1858, p. 133, pl. 23, fig. 8; pl. 60, fig. 8.

Lull 1904 A, p. 498.

Type specimens, Cat. Nos. 42/6 and 42/7, Amherst collection, from Turners Falls, Mass., the only known locality.

Specific Characters. — Pes: Length, from extreme rear of track, of digit II, 36 mm.; III, 72 mm.; IV, 56 mm.; entire foot, 72 mm. Width of foot, 18 mm. Divarication of digits cannot be measured.

Length of step, 90 mm. The feet turn outward so that the heels are in line, the tail trace usually passing through them. The toes curve inward.

"This is a very striking track, and, though obscure as to details, is readily recognizable. It was apparently formed by a small dinosaur of unknown affinities" (Lull).

Selenichnus breviusculus E. Hitchcock

E. Hitchcock 1858, p. 134, pl. 23, fig. 9; pl. 60, fig. 7.

Lull 1904 A, p. 499.

Type, Cat. No. 44/10, Amherst collection, a series of twenty-three tracks passing in a curved line across the rain-marked slab. From Turners Falls, Mass.

Specific Characters. — Pes: Length of foot, 46 mm.; of the step, 58 mm.; width of trackway, 38 mm.

This obscure form is distinguishable from *S. falcatus* mainly by its much smaller size, but is more numerous.

Localities. — Lily Pond, ferry above Turners Falls, ferry at Turners Falls, and Turners Falls, Mass., within the easy range of one individual.

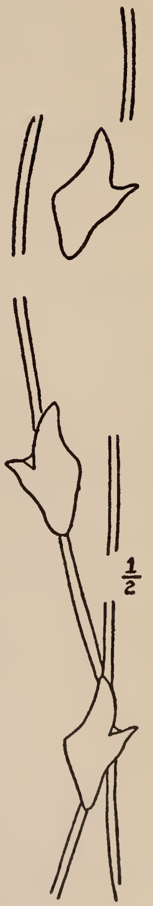

FIG. 60. — *Selenichnus breviusculus.* One-half nat. size. Original. The tail was raised and impressed a second time during the stride.

Suborder **ORTHOPODA**[1]

Lull 1904 A, p. 499.

Subordinal Characters. — The footprints give evidence of the following characters: "Bipedal dinosaurs, with a mesaxonic, generally digitigrade, tetradactyl or [functionally] tridactyl foot, armed with more or less blunted claws. The foot ranges from the plantigrade, functionally tetradactyl type of *Otozoum,* through the digitigrade (occasionally calcigrade while resting) and functionally tridactyl pes of *Anomœpus.* . . . . The manus is pentadactyl with blunt claws, and, while occasionally touching the ground in the resting position, is [apparently]

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[1] A letter received from Dr. Heilman, under date of October 18 1913, contains the following criticism of a part of the memoir, which was sent to him in advance with the permission of Professor Rice:

"I am not able to agree with your statement, that those dinosaurs were vegetable eaters. Of course I can not prove the contrary, but a footprint seems to never used for locomotion; it is considerably smaller than the pes. A caudal trace is occasionally present in some genera" (Lull).

Family ANOMŒPODIDÆ

Lull 1904 A, p. 499.

Family Characters.—"Bipedal in gait, the manus impressing only when resting. Pes tetradactyl, digitigrade, with elongate metatarsal segment upon which the animal sits (calcigrade) while at rest. Hallux half rotated, insistent, and subfunctional, but rarely impressing. Pes ornithoid. Manus pentadactyl. . . . . Claws bluntly rounded" (Lull).

Genera: *Anomœpus, Sauropus, Apatichnus;* possibly *Corvipes,* and others.

Genus **Anomœpus** E. Hitchcock

E. Hitchcock 1848, p. 220.

Lull 1904 A, p. 500.

"In addition to the family characters above mentioned, this genus may be readily recognized by its very characteristic foot, in which the toes are quite widely divergent, especially digit IV. There is also a doubling of many of the lines over the articulations of the phalanges similar in appearance to those of the human hand. Limbs only moderately long; when resting, considerable weight is borne on the hand — a point of difference with the succeeding genus. There is an occasional tail trace and

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me a too small verification of this assertion. I think it not sufficient to show, that the animal had a hand different from, for instance, the Thecodontosaurs with their powerful claw-bearing pollex. We must also compare with the recent forms, whose habits we know quite well. And here you can not state from a hand of a reptile, whether the animal has a carnivorous or herbivorous diet. The greatest part of them are carnivorous, but their hand has no grasping power.

"The prey also is of many different kinds. You need only imagine mollusks, snails, slugs and such slowly-moving animals to see that a special-shaped hand is not required for feeding on these. When we, for instance, look at the *Varanus niloticus,* which, according to the investigations of Lönnberg, feeds on large hard-shelled land snails, then we see the teeth and jaws much changed to this purpose, but not the hand. In fact the hand of this reptile is shaped quite as that of *Amblyrhynchus cristatus* from the Galapagos islands, which feeds only on sea-weed.

"Above all you do not know the teeth of the dinosaurs which have made the footprints, and therefore I do not think you are able to convince us, that they were vegetarians."

In reply to this criticism it may be said that all of the modern reptiles are essentially quadrupedal, hence the hands are modified for locomotion only and therefore show no adaptations in correlation with feeding habits. In the dinosaurs which were bipedal, however, a certain type of hand *invariably* goes with carnivorous and another with herbivorous teeth. No known carnivore could have made manus impressions comparable with those of *Anomœpus;* on the other hand, *Camptosaurus,* a typical Morrison orthopod, would have produced an imprint of essentially the same character. Hence, while a strictly herbivorous diet on the part of *Anomœpus* is not absolutely demonstrable, the evidence certainly points that way.

an ischial callosity impression. There is also a pad on the sole of the foot in line with and in addition to the four which are usually found on digit IV" (Lull).

Anomœpus scambus E. Hitchcock

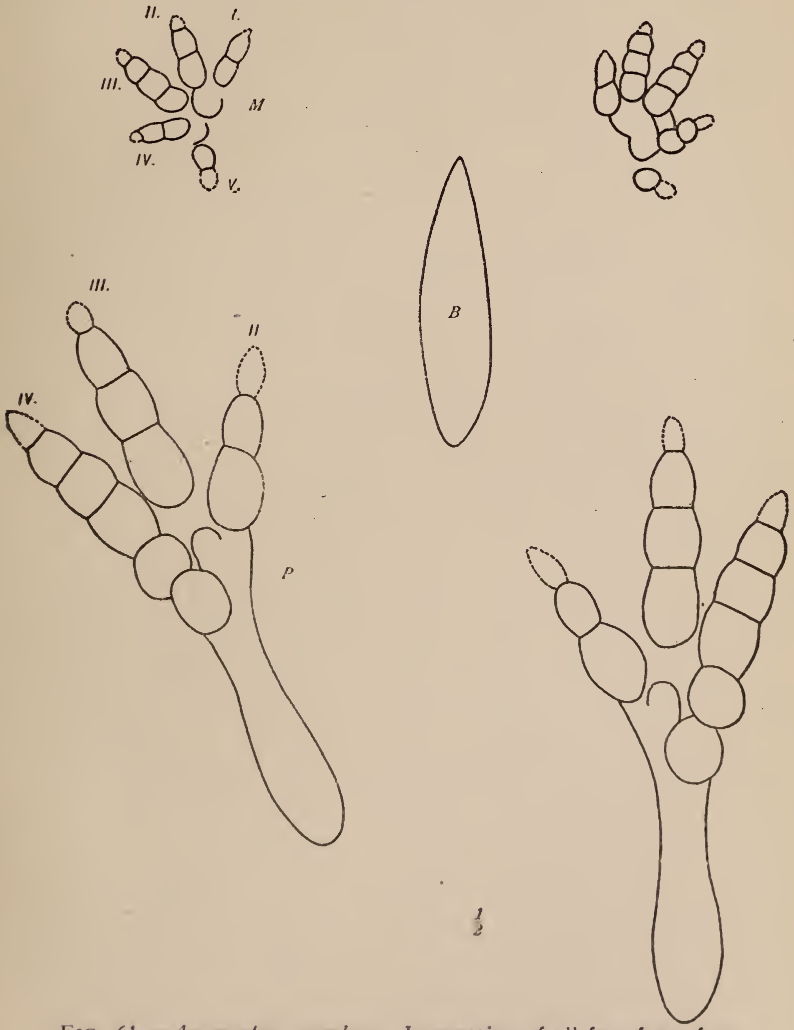

Fig. 61.—*Anomœpus scambus*. Impression of all four feet of an individual seated. *B*, impression of breast. One-half nat. size. After Lull.

E. Hitchcock 1848, p. 222, pl. 13, figs. 1-6.

Anomœpus minor E. Hitchcock 1858, p. 57, pl. 9, figs. 1-2; pl. 34, fig. 2.

Lull 1904 A, p. 500, fig. 18.

Type specimens, Cat. Nos. 16/5 and 34/40, Amherst collection, on red shale, the latter from Turners Falls, Mass.

Specific Characters.—Manus: Length of digit I, 24 mm.; II, 29 mm.; III, 32 mm.; IV, 24 mm.; V, 15 mm. Divarication of digits I and II, 17.5° to 43°; II and III, 22° to 29°; III and IV, 24° to 50°; IV and V, 55° to 87°; I and V, 120° to 152°.

Pes: Digit I, unknown. Length of digit II, 49 mm. to 57 mm.; III, 60 mm. to 80 mm.; IV, 63 mm. to 83 mm. Length of foot, 95 mm.; with the heel, 168 mm. to 210 mm. Divarication of digits II and III, 20° to 35°; III and IV, 22° to 23°.

Length of step, 230 mm. Width of trackway, 200 mm.

See also plate vi.

Localities.—Ferry above Turners Falls, ferry at Turners Falls, Turners Falls, Field's orchard at Gill, Moody's corner, South Hadley, Mass.

Anomœpus intermedius E. Hitchcock

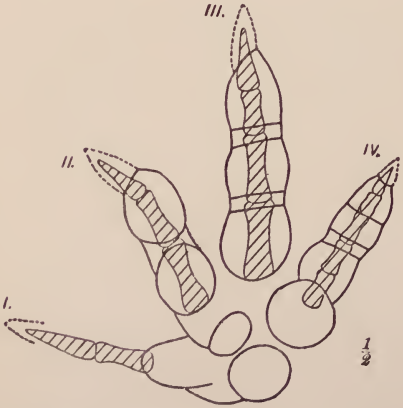

FIG. 62.—*Anomœpus intermedius.* Animal walking. One-half nat. size. After Lull.

Æthyopus minor (in part) E. Hitchcock 1848, p. 179, pl. 4, figs. 2, 3; 1858, p. 69, pl. 12, fig. 4; pl. 40, fig. 1; pl. 46, fig. 3; pl. 57, fig. 4.

Plesiornis quadrupes E. Hitchcock 1858, p. 102, pl. 17, fig. 7; pl. 35, figs. 1-2; pl. 45, fig. 5.

E. Hitchcock 1865, pp. 2, 7, pl. 1, fig. 1; pl. 15, fig. 1. This species is based upon part of *Brontozoum isodactylum* E. Hitchcock 1858, p. 69.

Apatichnus holyokensis C. H. Hitchcock 1889, pp. 118, 123, 124.

Lull 1904 A, p. 501, figs. 19-21; 1904 B, p. 145, fig.

Type specimen, Cat. No. 48/1, Amherst collection, on reddish sandstone from Turners Falls, Mass. Cat. Nos. 54/13 and 52/4 were used for a composite figure by Lull (1904 A, fig. 21), the latter specimen having been identified by C. H. Hitchcock as *Apatichnus holyokensis,* the type of which is preserved in the Mount Holyoke College Museum. The latter species I consider synonymous with *Anomœpus intermedius.*

Specific Characters. — Manus: Length of digit I, 15 mm.; II, 28 mm.; III, 30 mm.; IV, 23 mm. Divarication of digits I and II, 33°; II and III, 22°; III and IV, 68°; IV and V, 25°.

Pes: Length of digit II, 52 mm.; III, 73 mm.; IV, 57 mm.; entire foot, 105 mm., including heel, 173 mm. Divarication of digits I and II, 56°; II and III, 20°; III and IV, 35°; I and IV, 110°+.

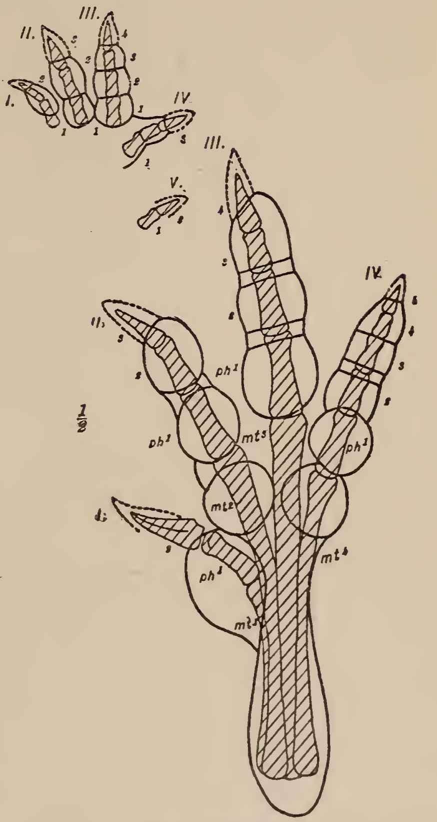

FIG. 63.—*Anomœpus intermedius.* Animal seated. One-half nat. size. After Lull.

Length of step varies in the same animal from 140 to 235 mm., average about 220 mm. Width of trackway, 150 to 180 mm.

A. intermedius differs from *A. scambus* in the greater divarication of lateral digits, greater relative stoutness of foot, and relatively shorter heel.

Localities. — Ferry above Turners Falls, ferry at Turners Falls, Turners Falls, Field's orchard in Gill, Dickinson quarry in South Hadley, Mass.; ?Wethersfield, Conn.; Whitehall, N. J.

Anomœpus curvatus E. Hitchcock

E. Hitchcock 1865, p. 5, pl. 1, fig. 2; pl. 15, fig. 2.

Lull 1904 A, p. 502, fig. 22; 1904 B, p. 146, fig.

Type specimen, Cat. No. 52/10, Amherst collection, from the Lily Pond at Turners Falls, Mass.

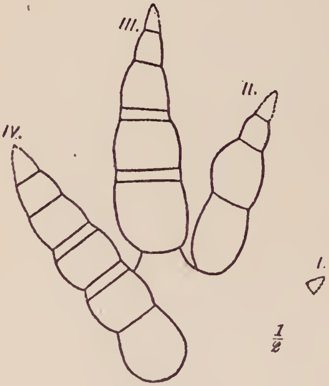

Fig. 64.—*Anomœpus curvatus.* One-half nat. size. After Lull.

Specific Characters. — Manus unknown. Pes: Length of digit II, 50 mm.; III, 64 mm.; IV, exclusive of sole pad, 55 mm.; entire foot, 98 mm. Length of heel unknown.

Length of step, 230 to 250 mm.

This species approximates *intermedius* very closely, being distinguished chiefly by its smaller size, by the less divergent outer toe, and by a distinct inward curvature to the middle toe, which is also present, though to a less degree, in the fourth toe.

Localities: Lily Pond, ferry above Turners Falls, ferry at Turners Falls, Turners Falls, Field's orchard in Gill, and South Hadley, Mass.

Anomœpus crassus (C. H. Hitchcock)

Apatichnus crassus C. H. Hitchcock 1889, pp. 118, 122, 124.

Lull 1904 A, p. 503, fig. 23.

Type specimen on a large slab of red sandstone and its counterpart preserved in the Geological Museum at Rutgers College, from Whitehall, N. J.

Specific Characters. — Manus: Width of impression, 60 mm.; length, 60 mm. Pes: Length of digit II, 85 mm.; III, 102 mm.; IV, not including the sole pad, 83 mm.; including the sole pad, 120 mm.; entire foot, 190 mm. Distance between lateral claws, 140 mm. Divarication of digits I and II, 80°; II and III, 32°; III and IV, 40°, II and IV, 72°.

Length of step, 387 mm.

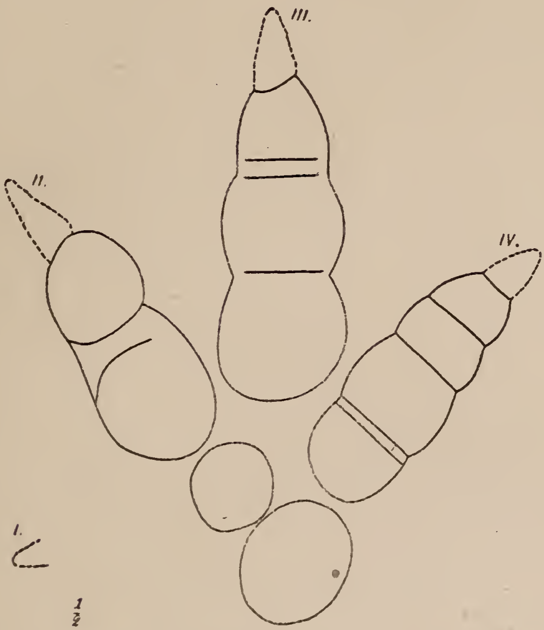

Fig. 65.—*Anomœpus crassus.* One-half nat. size. After Lull.

This species resembles *A. intermedius*, but is considerably larger and the hallux is rotated further to the rear. It may prove to be identical in part with the old *Eubrontes expansus* E. Hitchcock abandoned after the publication of the Fossil Footmarks of 1848.

Locality. — Only that given above; not reported from the Connecticut valley.

Anomœpus minimus E. Hitchcock

E. Hitchcock 1865, p. 5, pl. 2, fig. 2.

Lull 1904 A, p. 503, fig. 24.

Type specimen, Cat. No. 55/112, Amherst collection, from Field's orchard, Gill, Mass. Cat. No. 55/21, from the same locality, was also used by Lull in drawing the figure (fig. 66) and therefore becomes a plesiotype.

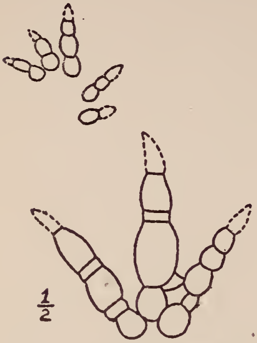

FIG. 66.—*Anomœpus minimus.* One-half nat. size. After Lull.

Specific Characters.—Manus: Length of digit I, 12 mm.; II, 14 mm.; III, 21 mm.; IV, 14 mm.; V, 10 mm. Divarication of digits I and II, 40°; II and III, 25°; III and IV, 48°; IV and V, 28°.

Pes: Length of digit II, 35 mm.; III, 50 mm.; IV, 33 mm.; entire foot, 54 mm.; heel, unknown. Divarication of digits II and III, 40°; III and IV, 35°. Hallux impression absent in the type.

Distinguishable from all other species of *Anomœpus* by its small size and delicate proportions.

Localities. — Ferry at Turners Falls, Field's orchard at Gill, South Hadley, Mass.

Possibly some of the specimens referred to *A. gracillimus* belong here, which would widen the rather restricted range of the species.

Anomœpus gracillimus (E. Hitchcock)

Ornithoidichnites gracillimus E. Hitchcock 1844, p. 305.

Eubrontes gracillimus E. Hitchcock 1845, p. 23.

Brontozoum gracillimum E. Hitchcock 1848, p. 175, pl. 2, fig. 3.

Grallator gracillimus E. Hitchcock 1858, p. 73, pl. 13, fig. 5; pl. 39, fig. 2.

C. H. Hitchcock, in E. Hitchcock 1865, p. 6.

Lull 1904 A, p. 504.

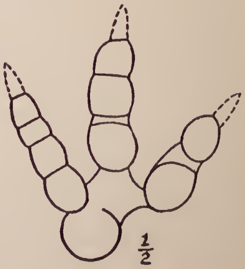

FIG. 67.—*Anomœpus gracillimus.* One-half nat. size. Original.

Type, Cat. No. 50/1, Amherst collection, on red sandstone, from Turners Falls, Mass.

Specific Characters. — Manus: unknown. Pes: Length of digit II, 39 mm.; III, 50 mm.; IV, 46 mm.; entire foot, 64 mm.

Length of step, 180 to 200 mm. Width of trackway, 90 mm.

This species differs from *minimus* in being a somewhat larger, heavier track resembling more nearly in general appearance *intermedius,* as though it were the young of that species.

Localities. — Ferry above Turners Falls, ferry at Turners Falls, Turners Falls, Field's orchard in Gill, Dickinson quarry in South Hadley, and ?Chicopee Falls, Mass.; Wethersfield and Middlefield (posterior shales), Conn.; near Goldsboro, York county, Penn. Its presence in the posterior shales makes *Anomœpus gracillimus* the earliest recorded species of the genus in time.

Anomœpus cuneatus C. H. Hitchcock

C. H. Hitchcock 1889, pp. 118, 125.

Lull 1904 A, p. 505.

Type specimen, Cat. No. 105, Mount Holyoke collection, from Wethersfield, Conn.

Specific Characters. — Manus: but three digits impressing in the only known track. Length 24 mm., including what may be a wrist impression, 30 mm.; distance between lateral claws, 20 mm.

Pes: Length of digit II, 48 mm.; of III, 58 mm.; of IV, 44 mm. Between lateral toes, 43 mm. Divarication of digits II and III, 36.5°; III and IV, 7.5°; II and IV, 43.5°.

Length of step, 330 to 460 mm. Width of trackway, 178 mm.

Localities. — Howland farm in Gill, Lily Pond, Dickinson quarry in South Hadley, Mass.; Wethersfield, Conn.

Anomœpus isodactylus C. H. Hitchcock

C. H. Hitchcock 1889, pp. 118, 124.

Lull 1904 A, p. 505, fig. 25.

Type specimen, Cat. No. 128 and its counterpart, No. 142, Mount Holyoke collection, from South Hadley, Mass.

Specific Characters. — Manus: four digits impressed (from Cat. No. 2097, Yale collection); length of digit I, 30 mm.; II, 36 mm.; III, 40 mm.; IV, 30 mm.; length of hand, including a wrist impression, 83 mm. Divarication of digits I and II, 20°; II and III, 23°, III and IV, 50°; I and IV, 93°.

Pes: (from type) length of digit I, 43 mm.; II, 63 mm.; III, 72 mm.; IV, including sole pad, 101 mm.; entire foot, 115 mm., including the heel, 230 mm. The basal pads of the hallux are impressed as well as the claw. Divarication of digits I and II, 50°; II and III, 29°; III and IV, 30°.

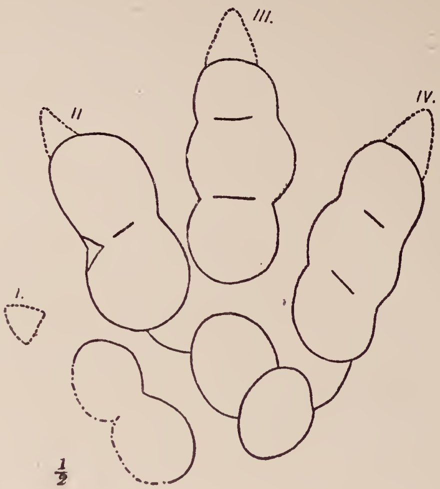

FIG. 68.—*Anomœpus isodactylus.* One-half nat. size. After Lull.

Length of step, 205 mm.

A large, heavy, broad-toed track.

Localities.—Turners Falls, Dexter Marsh's quarry in Montague, and South Hadley, Mass.

Genus **Sauropus**[1] E. Hitchcock

E. Hitchcock 1845, p. 24.
Fulicopus E. Hitchcock 1845, p. 23.
Anomœpus E. Hitchcock 1848, p. 220 (in part).
Æthyopus E. Hitchcock 1848, p. 178 (in part).
Amblonyx E. Hitchcock 1858, p. 71.
Chimœra E. Hitchcock 1858, p. 118.
Chimœrichnus C. H. Hitchcock 1871, p. xxi.

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[1] This genus *Sauropus* is totally unrelated to that described by I. Lea in 1849 from the Coal Measures of Pennsylvania though there is a suggestive similarity in the tracks. O. P. Hay (1902) has substituted the term *Palæosauropus* for the *Sauropus* of Lea.

Fulicopus Lull 1904 A, p. 505.

Generic Characters. — Distinguished from *Anomœpus* by the greater size, especially of the pes, less acuminate claws, less divarication of the digits, and the absence of the sole pad in addition to the four phalangeal pads normally belonging to digit IV. An ischial callosity may be present. Foot resembles that of *Anchisauripus* but may be distinguished therefrom by the non-rotated hallux and by the occasional impression of the manus and long heel when the animal is resting.

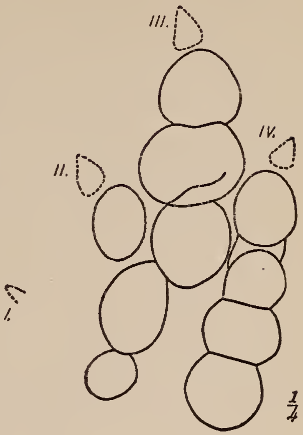


Fig. 69.—*Sauropus barrattii.* Animal walking. One-fourth nat. size. After Lull.

Sauropus barrattii E. Hitchcock

Sauroidichnites barrattii E. Hitchcock 1837, p. 175; 1841, pp. 477, 478, pl. 30, fig. 1.

Ornithoidichnites lyellii E. Hitchcock 1843, pp. 257-258; pl. 11, fig. 1.

E. Hitchcock 1845, p. 24.

Fulicopus lyellianus E. Hitchcock 1845, p. 23.

Æthyopus lyellianus E. Hitchcock 1848, p. 178, pl. 4, fig. 1.

Anomœpus barrattii E. Hitchcock 1848, p. 225, pl. 14, fig. 1.

Amblonyx lyellianus E. Hitchcock 1858, p. 71, pl. 13, fig. 2; pl. 38, figs. 1, 2; pl. 57, fig. 6.

Anomœpus major E. Hitchcock 1858, p. 56, pl. 8.

Chimæra barrattii E. Hitchcock 1858, p. 118, pl. 21, figs. 1, 3 (in part).

Chimærichnus barrattii C. H. Hitchcock 1871, p. xxi.

Fulicopus lyellianus Lull 1904 A, pp. 506-508, figs. 26-28.

This species has the most complex synonymy of all because of the fact that separate names were given to the impression of the hand, which was supposed to be that of a hind foot, and also to the foot both in the walking and again in the seated posture.

In 1837 Hitchcock described and figured the manus under the name of *Sauroidichnites barrattii,* which became, in the 1845 list, *Sauropus barrattii.* The pes was first described and figured under the name of *Ornithoidichnites lyellii* in 1843, becoming *Fulicopus lyellianus* in the list of 1845. Thus both anatomically and by the laws of priority the name of the manus impression, *Sauropus barrattii,* takes precedence. This manus impression was called *Anomœpus barrattii* in the publication of 1848, while in 1858 what was supposed to be the same species was renamed *Chimæra barrattii;* but, while the fore foot figured (pl. 21, fig. 3) is the same as before, the hind foot (fig. 1) is new, although strongly suggestive of the *Anomœpus scambus* figured in 1848, pl. 13, fig. 3. In 1871 C. H. Hitchcock, finding the name *Chimæra* preoccupied, substituted that of *Chimærichnus.* Of this series of names *Sauropus barrattii* alone is valid.

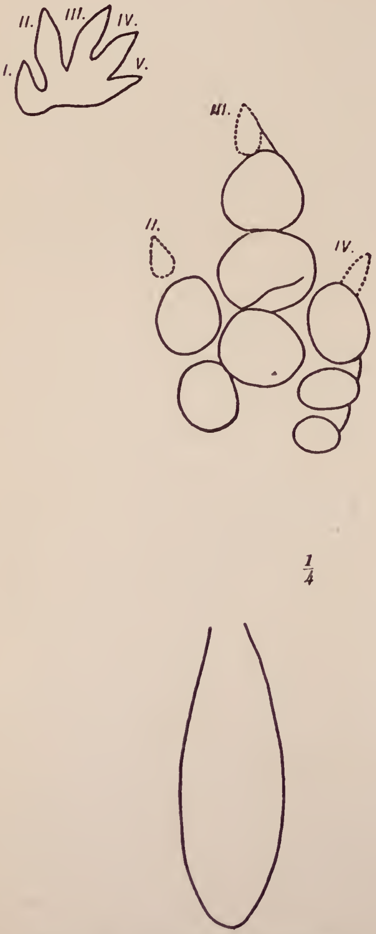


FIG. 70.—*Sauropus barrattii.* Animal seated. One-fourth nat. size. After Lull.

To return to the hind foot impression, *Fulicopus lyellianus* of the 1845 list was changed to *Æthyopus lyellianus* in that of 1848 and to *Amblonyx lyellianus* in 1858. In 1858 Hitchcock further described what he supposed to be a new form, basing his description upon the impression of a seated individual which he called *Anomœpus major.* This animal Lull showed in 1904 (p. 507) to be not only the same species but the same *individual* as that which made the type track of *Fulicopus lyellianus,* both type impressions appearing on the same slab, Cat. No. 1/1 of the Amherst College collection, and both showing a peculiar unique distinction in the right foot. Thus no fewer than ten names in all have been given to this remarkable form.

Type specimens, Cat. Nos. 1/1 and 1/7, Amherst collection, from Turners Falls, Mass.

Specific Characters. — Manus: Length of digit I, 31 mm.; II, 38 mm.; III, 40 mm.; IV, 33 mm.; V, 20 mm. Divarication

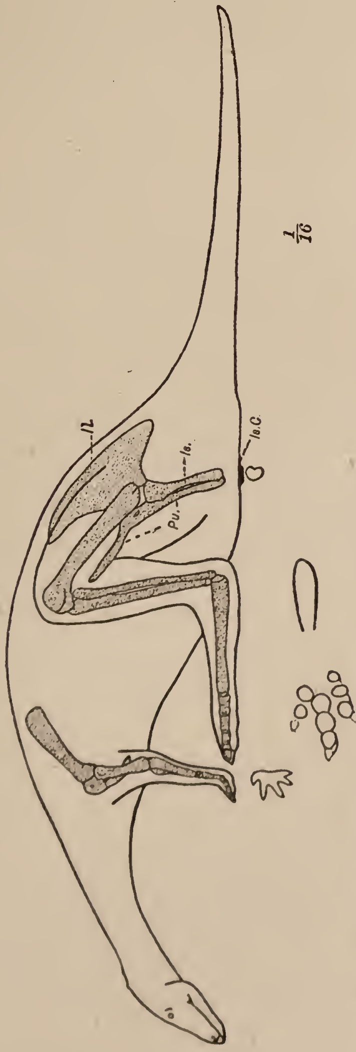


Fig. 71. — Restoration of *Sauropus* in seated posture. One-sixteenth nat. size. After Lull.

of digits I and II, 6°; II and III, 32°; III and IV, 20°; IV and V, 26°.

Pes: Length of digit I, 83 mm.; II, 103 mm.; III, 147 mm.; IV, 156 mm.; entire foot, 220 mm., including heel, 427 mm.; breadth of heel, 50 mm. Distance between lateral claws, 110 mm. Divarication of digits I and II, 40°; II and III, 11.5°; III and IV, 14°.

Length of step, 765 mm. Width of trackway, 127 mm.

The resting posture of *Sauropus* differs from that of *Anomœpus* in that in the former the bulk of the weight is borne upon the hind limbs, the manus making an extremely light, variable impression without phalangeal pads, and with more acuminate claws.

Localities. — Lily Pond, Turners Falls and Field's orchard in Gill, Mass.; not a wide-spread species though possibly some of the specimens properly referable to it have been referred to *Anchisauripus exsertus.*

Genus **Apatichnus** E. Hitchcock

E. Hitchcock 1858, p. 99.

Lull 1904 A, p. 508.

Generic Characters. — Bipedal, digitigrade, functionally tridactyl, claws on pes acuminate; caudal trace.

Apatichnus differs from *Anomœpus* in the much shorter hallux, less divarication between digits I and III, greater between III and IV.

Apatichnus circumagens E. Hitchcock

E. Hitchcock 1858, p. 100, pl. 17, fig. 5; pl. 35, fig. 6.

Lull 1904 A, p. 508, fig. 29.

Type specimen, Cat. No. 21/2, Amherst collection, on red micaceous sandstone from the ferry at Turners Falls, Mass.

Specific Characters.— Manus: Turned inward toward the median line.

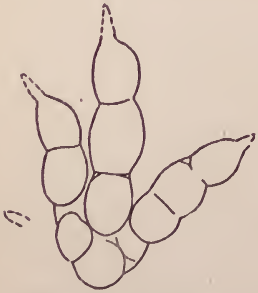


FIG. 72.—*Apatichnus circumagens.* Nat. size. After Lull.

Pes: Length of digit I, 25 mm.; II, 35 mm.; III, 62 mm.; IV, 53 mm.;

entire foot, 75 mm. Divarication of digits I and II, 53°; II and III, 18°; III and IV, 46°; I and IV, 116°. Length of foot and heel of a smaller specimen, 127 mm.; of the foot alone, half that length.

Average length of step, 240 mm.

Caudal trace sinuous, not always present.

Localities. — Turners Falls, Field's orchard in Gill, and South Hadley, Mass.

Apatichnus minor (E. Hitchcock)

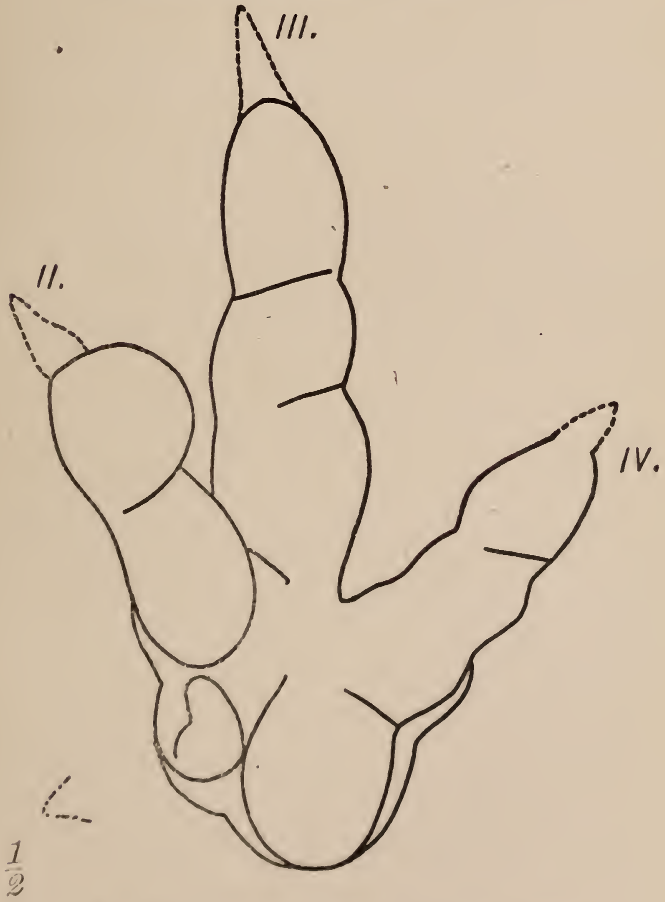


FIG. 73.—*Apatichnus minor.* One-half nat. size. After Lull.

Gigantitherium minus E. Hitchcock 1858, p. 95, pl. 17, fig. 1; pl. 41, fig. 2; pl. 42, fig. 2.

Lull 1904 A, p. 509, fig. 30.

Type specimen, Cat. No. 1/3, Amherst collection, on micaceous shale from Lily Pond, Turners Falls, Mass.

Specific Characters.— Manus: Unknown. Pes: Length of digit II, 108 mm.; III, 147 mm.; IV, 146 mm.; entire foot, 225 mm.; distance between lateral claws, 160 mm. Divarication of digits II and III, 20°; III and IV, 43.5°.

Length of step, 630 mm. Width of trackway, 167 mm. Caudal trace straight, interrupted at each step.

Localities. — Lily Pond, ferry above Turners Falls, Turners Falls, South Hadley, and ?Moody's corner, Mass.

Family OTOZOIDÆ.

Lull 1904 A, p. 513.

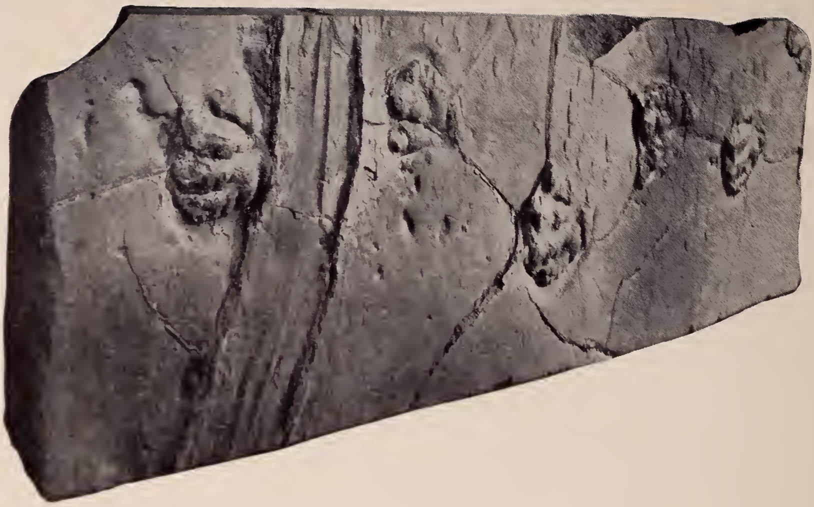
Family Characters. — Bipedal. Manus rarely impressing. Pes plantigrade, functionally tetradactyl, hallux non-rotated. Digits broad, with well marked phalangeal pads; claws more or less rounded. Manus apparently pentadactyl, relatively small. Occasional tail trace.

Genus **Otozoum** E. Hitchcock

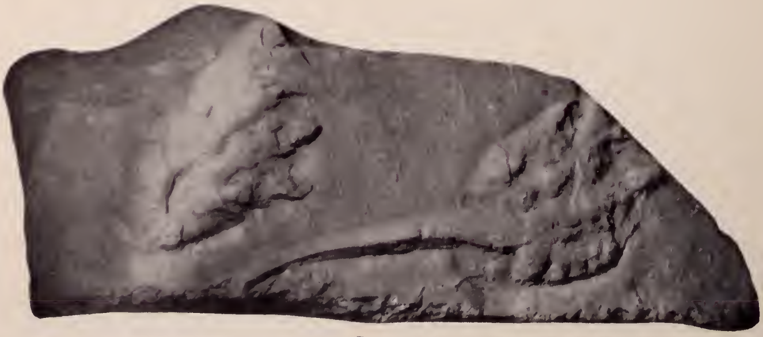
E. Hitchcock 1847, p. 54; 1848, p. 214; 1858, p. 123.

Lull 1904 A, p. 513.

Generic Characters. — Those of the family. The footprints of this mysterious animal are utterly unique, and no dinosaur known to me from the skeleton has a pes which could possibly make such a track. It may be, however, that a more thorough study of the material collected at Phœnixville, Penn., and now preserved in the American Museum of Natural History may aid in its interpretation. It appears abruptly toward the close of Newark deposition, being represented by but two species, the huge *O. moodii* from South Hadley, Mass., and Portland, Conn., and a smaller, possibly earlier, phase, occurring in the Turners Falls region. The so called "web" (Hitchcock 1858, p. 123; Lull 1904 A, p. 513) proves to be nothing more than the wave of plastic mud displaced by the animal's weight, as specimens,



A.



B.

Plate XII.—*Otozoum moodii.*

A, showing "flange"-like wave of mud displaced by the animal's weight.
B, with a caudal trace as in "*O. caudatum*". Original.

such as Cat. No. 680, from Portland, preserved at Wesleyan University (see Pl. xii A), clearly show. The "web" is *convex* where the phalangeal pad impressions are *concave,* and the dermal papillæ so strikingly impressed upon the actual track abruptly cease when the "web" is reached. The same phenomenon may be observed in *Anchisauripus sillimani* from Portland and in *Chirotherium* spp. of the Old World.

Otozoum moodii E. Hitchcock

E. Hitchcock 1847, p. 55, fig. 1; 1848, p. 214, pl. 12, fig. 1; 1858, p. 123, pl. 22; pl. 23, fig. 1; pl. 33, figs 4-5; pl. 46, fig. 5.

Otozoum caudatum C. H. Hitchcock 1871, p. xxi; 1889, pp. 119, 127.

Lull 1904 A, p. 513, pl. 72, figs. E, F, G.

Type specimens, Cat. No. 5/14, Amherst collection, in high relief on coarse sandstone from Moody's corner, South Hadley, Mass.; also Nos. 4/4 and 4/1. The latter's counterpart, No. 3/1, is also preserved, but the layer of red mud, upon which the animal actually walked, could not be saved.

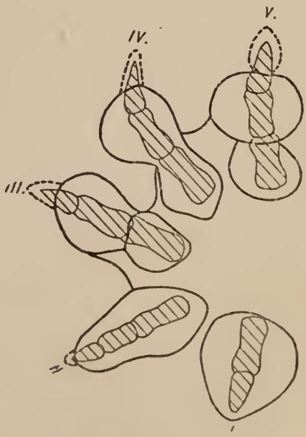


FIG. 74.—Handprint of *Otozoum moodii.* One-fourth nat. size. After Lull.

Specific Characters. — Manus: Length of digit I, 56 mm.; II, 80 mm.; III, 92 mm.; IV, 98 mm.; V, 90 mm.; entire hand, 206 mm. Divarication of digits I and II, 53°, II and III, 40°; III and IV, 36.5°; IV and V, 40°.

Pes: Length of digit I, 196 mm.; II, 230 mm.; III, 192 mm.; IV, 202 mm.; entire foot, 490 mm.; distance between lateral tips, 380 mm.

Length of step, about 800 mm.

The manus is preserved, to my knowledge, in only one instance, No. 5/14, where both hands are impressed as the animal sat. It seems hardly possible that in all other specimens the manus imprint is obliterated by that of the pes, so that evidence for the bipedal gait is still unchallenged. Bipedality, however, implies speed adaptation and digitigrady, at least while in action. *Otozoum,* on the

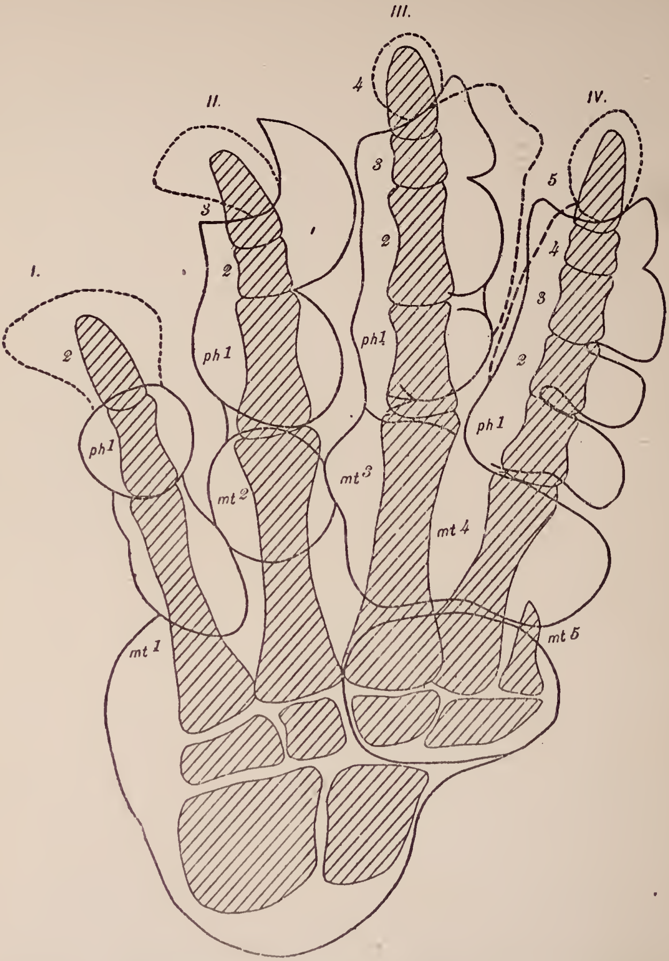


Fig. 75.— *Otozoum moodii*. One-fourth nat. size. Modified from Lull.

contrary, with its massive plantigrade foot and ponderous tread, is the antithesis of a cursorial type. Apparently the mystery of this majestic type is as far from solution as ever.

Cat. No. 183, Wesleyan University collection, shows a tail trace, as does No. 725, both from Portland (see Pl. xii B). The former was the type of *O. caudatum* C. H. Hitchcock.

Localities — Moody's corner, South Hadley, Mass.; Portland, Conn. (See also *O. minus* n. sp.)

Otozoum minus, n. sp.

Type specimen, Cat. No. 2046, Yale collection, from the Horse Race at Montague, Mass., one of a series of twenty-four tracks.

Specific Characters. — Manus: Unknown. Pes: Length of digit I, about 120 mm.; II, 128 mm.; III, 140 mm.; IV, 137 mm.; entire foot, as impressed (without the posterior heel pad), 228 mm. Distance between lateral tips, about 170 mm. Divarication of digits I and II, 17°; II and III, nearly parallel; III and IV, 22°; I and IV, 38°.

Length of stride unrecorded.

Hitchcock (1858, p. 125) says in speaking of *Otozoum:*

"Turners Falls at the ferry is another locality of these tracks. From the small size of some of the specimens there, I have suspected that they were made by a second species; but my specimens are somewhat broken, and I leave it for others to decide this question."

The splendid series of twenty-four successive tracks at Yale, of which but one, however, is accessible at this writing, leads me to erect for its inclusion the new species which Hitchcock has suggested. It is much smaller and is probably somewhat antecedent in time to *O. moodii* to which it may have been ancestral.

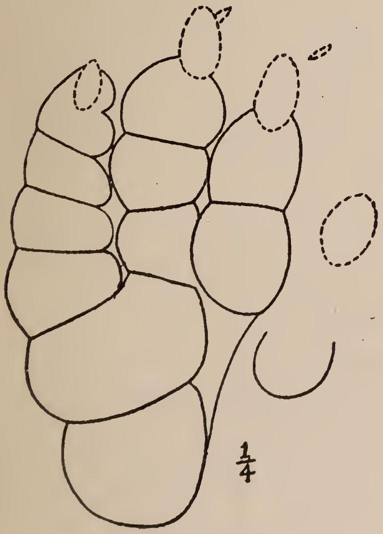


FIG. 76.—*Otozoum minus.* One-fourth nat. size. Original.

Localities. — Horse Race, Turners Falls, and ? the canal at Montague, Mass.

Genus ? **Chirotherium** Kaup

? **Chirotherium parvum** (C. H. Hitchcock)

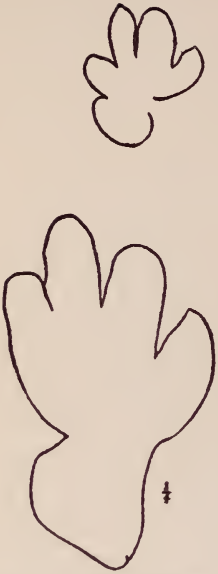


FIG. 77.—?*Chirotherium parvum*. One-fourth nat. size. Drawn by C. H. Hitchcock.

Otozoum parvum C. H. Hitchcock 1889, pp. 119, 122, 127.

? *Otozoum parvum* Lull 1904 A, p. 515.

Type specimen preserved in the museum of Lafayette College, Easton, Pa., from Milford, N. J., the only known locality.

Specific Characters. — Manus: Length of digit I, 30 mm.; II, 34 mm.; III, 35 mm.; IV, 25 mm.; V, 20 mm.; entire hand, 75 mm. Divarication of digits I and II, 29°; II and III, 16°; III and IV, 40°; IV and V, 14°.

Pes: Length of digit I, 76 mm.; II, 120 mm.; III, 128 mm.; IV, 102 mm.; entire foot, 190 mm. Divarication of digits I and II, 24°; II and III, 16°; III and IV, 14°; I and IV, 54°.

Length of step unrecorded.

In general aspect this track is more *Chirotherium*- than *Otozoum*-like; if of the latter genus it is surely more primitive than either of the Connecticut valley forms. It compares in size very favorably with *Chirotherium storetonense*[1] of the Lower Keuper of Storeton, Liverpool, England.

? REPTILIA

Incertæ Sedis

Forms Habitually Bipedal

What these forms were it is difficult to conceive; but as bipedality has been evolved a number of times (*e. g.*, dinosaurs, birds, several modern lizards, marsupials, rodents, man, etc.), it does not necessarily follow that there may not have been other reptilian orders in which cursorial need impelled the animal to assume the erect or semi-erect pose. What these orders were we cannot, in the light of our present knowledge, ascertain. From this point on, therefore, an attempted classification into families and orders seems futile.

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[1] Lull, 1904 A, Pl. 72, figs. C, D.

Genus **Platypterna** E. Hitchcock

E. Hitchcock 1845, p. 25; 1858, p. 83.

Lull 1904 A, p. 515.

Generic Characters.— " Bipedal, tridactyl, plantigrade or digitigrade, generally with a broad, rounded heel. Digits narrow without pad impressions and but rarely showing distinct claws " (Lull).

Platypterna deanii E. Hitchcock

Ornithoidichnites deanii E. Hitchcock 1841, p. 493, pl. 42, figs. 31, 32.

Platypterna deanianus E. Hitchcock 1845, p. 25.

Platypterna deaniana E. Hitchcock 1848, p. 189, pl. 7, fig. 1; 1858, p. 83, pl. 14, fig. 4.

Platypterna deaniana Lull 1904 A, p. 516.

Type specimen, Cat. No. 32/26, Amherst collection, on fine red shale from Wethersfield, Conn.

Specific Characters. — Pes: Length of digit II, 38 mm.; III, 76 mm.; IV, 51 mm.; heel, length, 30 mm., breadth, 23 mm. Distance between lateral tips, 51 to 63 mm. Length of foot, 100 to 115 mm. Divarication of digits II and III, 40° to 45°; III and IV, 25° to 30°; II and IV, 60° to 70°.

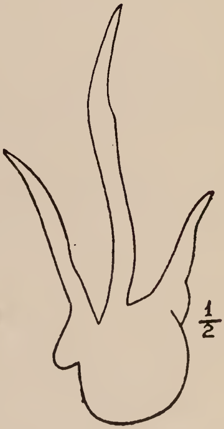


Fig. 78.—*Platypterna deanii.* One-half nat. size. Original.

Localities. — Turners Falls, Mass.; Wethersfield Cove and Wethersfield, Conn.

Platypterna concamerata (E. Hitchcock)

Harpedactylus concameratus E. Hitchcock 1848, p. 207, pl. 14, fig. 3.

Platypterna varica E. Hitchcock 1858, p. 85, pl. 14, fig. 8; pl. 47, fig. 4.

Lull 1904 A, p. 516.

Type specimen, Cat. No. 11/1, Amherst collection, on gray micaceous sandstone from Turners Falls, Mass.

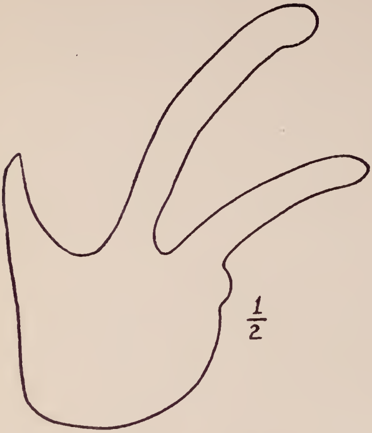


FIG. 79.—*Platypterna concamerata.* One-half nat. size. After Hitchcock.

Specific Characters.— Pes: Length of digit II, measured from the middle of the heel, 76 mm.; III, 91 mm.; IV, 51 mm.; heel, 28 mm. Width of the heel, 50 mm. Length of foot, 127 mm. Distance between lateral tips, 94 mm. Divarication of digits II and III, 23°; III and IV, 52°; II and IV, 75°.

Length of step, 200 mm. to 300 mm. Width of trackway, 280 mm.

Peculiarities, size and breadth of heel, curvature of toes and great width of trackway.

Localities.—Ferry at Turners Falls, and Turners Falls, Mass.

Platypterna digitigrada E. Hitchcock

E. Hitchcock 1858, p. 86, pl. 14, fig. 9; pl. 51, fig. 2.

Lull 1904 A, p. 516.

Type specimen, Cat. No. 36/16, Amherst collection, on shale from Turners Falls, Mass.

Specific Characters.— Pes: Length of digit II, 20 mm.; III, 30 mm.; IV, 23 mm.; distance between lateral tips, 40 mm.; width of heel, 20 mm.; length of foot, 50 mm. Divarication of digits II and III, 43°; III and IV, 37°; II and IV, 80°.

Length of step, 100 to 115 mm. Width of trackway, 76 mm.

Toes curve inward; thick, with acuminate claws.

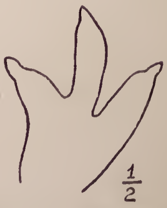


FIG. 80.—*Platypterna digitigrada.* One-half nat. size. After Hitchcock.

Localities. — Field's orchard in Gill, Lily Pond, and Turners Falls, Mass.

Platypterna tenuis E. Hitchcock

Ornithoidichnites tenuis E. Hitchcock 1841, p. 494, pl. 43, figs. 33, 34.

E. Hitchcock 1845, p. 25; 1848, p. 189, pl. 7, figs. 2, 3; 1858, p. 84, pl. 14, fig. 5; pl. 58, fig. 10.

Lull 1904 A, p. 517.

Type, Cat. No. 32/38, Amherst collection, on red shale from Wethersfield, Conn., the only known locality.

Specific Characters. — Pes: Length of digit II, 25 mm.; III, 42 mm.; IV, 35 mm.; breadth of heel, 15 mm.; distance between lateral tips, 48 mm.; length of foot, 69 mm. Divarication of digits II and III, 20° to 30°; III and IV, 25° to 30°; II and IV, 45° to 60°.

Length of step, 178 mm. Width of trackway, 50 mm.

A delicate, long-limbed, semi-plantigrade type.

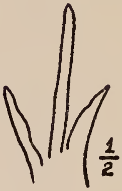


FIG. 81.—*Platypterna tenuis.* One-half nat. size. After Hitchcock.

Platypterna delicatula (E. Hitchcock)

Ornithoidichnites delicatus E. Hitchcock 1841, p. 497, pl. 45, fig. 40.

Calopus delicatulus E. Hitchcock 1845, p. 25.

E. Hitchcock 1848, p. 190, pl. 7, fig. 4; 1858, p. 84, pl. 14, fig. 6; pl. 58, fig. 8.

Lull 1904 A, p. 517.

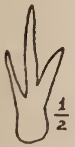


FIG. 82.—*Platypterna delicatula.* One half nat. size. After Hitchcock.

Type, Cat. No. 31/11, Amherst collection, on red shale from Wethersfield, Conn., the only known locality.

Specific Characters. — Pes: Length of digit II, 17 mm.; III, 28 mm.; IV, 19 mm.; heel, 10 mm. Width of heel, 8 mm.; distance between lateral tips, 15 mm. Divarication of digits II and III, 22°; III and IV, 18°; II and IV, 40°.

Length of step, 76 mm. Width of trackway, 50 mm.

The smallest species.

Platypterna recta (E. Hitchcock)

Harpedactylus rectus E. Hitchcock 1848, p. 209, pl. 5, fig. 5; pl. 24, fig. 7.

E. Hitchcock 1858, p. 84, pl. 14, fig. 7; pl. 47, fig. 3.

Lull 1904 A, p. 518.

Type specimen, Cat. No. 6/2, Amherst collection, on hard argillaceous sandstone, from Gill, Mass. Unique.

Specific Characters. — Pes: Length of digit II, 55 mm.; III, 80 mm.; IV, 60 mm. Width of heel, 45 mm.; distance between lateral tips, 63 mm.; length of foot impression, 95 mm. Divarication of digits II and III, 10°; III and IV, 27°; II and IV, 36°.

Length of step, 140 mm. Width of trackway, 140 mm.

Semi-plantigrade, toes straight, short limbs and wide body as in *P. concamerata*.

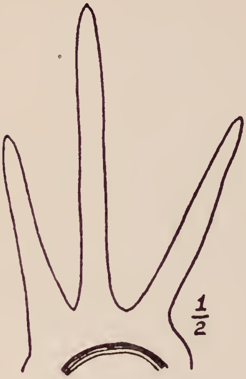


Fig. 83.—*Platypterna recta.* One-half nat. size. After Hitchcock.

Genus **Argoides** E. Hitchcock

E. Hitchcock 1845, p. 24.

Argozoum E. Hitchcock 1848, pp. 184-185; 1858, p. 81.

Lull 1904 A, p. 518.

Generic Characters. — "Bipedal, leptodactylous, tridactylous. Toes curved, the lateral ones more or less outward and upward behind, so as to be keel-shaped. Digitigrade, rarely showing a heel" (Lull).

Argoides minimus E. Hitchcock

Ornithichnites minimus E. Hitchcock 1836, p. 325, fig. 9.

Ornithoidichnites isodactylus E. Hitchcock 1841, p. 496, pl. 45, figs. 38, 39.

Ornithoidichnites minimus E. Hitchcock 1841, p. 496, pl. 45, fig. 41 (in part).

Argoides isodactyletus E. Hitchcock 1845, p. 24.

Argoides minimus E. Hitchcock 1845, p. 24 (in part).

Argozoum paridigitatum E. Hitchcock 1848, p. 187, pl. 6, figs. 3, 4; 1858, p. 82, pl. 14, fig. 3; pl. 35, fig. 4; pl. 39, fig. 1.

Argozoum minimum E. Hitchcock 1848, p. 187, pl. 6, fig. 5.

Plesiornis æqualipes E. Hitchcock 1858, p. 104, fig. (in part).

Argoides isodactyletus Lull 1904 A, p. 518.

Type specimen, Cat. No. 25/1, Amherst collection, on red shale with shrinkage cracks, from the Lily Pond, Turners Falls, Mass.

Specific Characters. — Pes: Length of digit II, 23 mm.; III, 33 mm.; IV, 25 mm.; distance between lateral tips, 27 mm.; entire foot, length, 30 mm. Divarication of digits II and III, 40° to 50°; III and IV, 40° to 50°; II and IV, 80° to 100°.

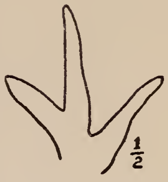


FIG. 84.— *Argoides minimus.* One-half nat. size. After Hitchcock.

Length of the step, 152 mm. Width of the trackway, 43 mm.

The size, coupled with extreme length of limb in this form, strongly suggests the genus *Grallator.*

Localities. — Horse Race, Gill, Lily Pond, Turners Falls, Mass.; and (*Plesiornis æqualipes*) Wethersfield Cove, Conn.

Argoides macrodactylus (E. Hitchcock)

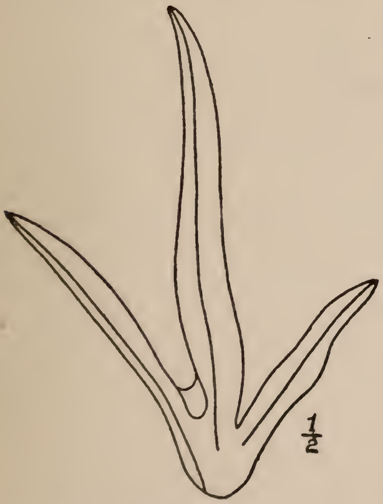


FIG. 85. — *Argoides macrodactylus.* One-half nat. size. Original.

Ornithoidichnites macrodactylus E. Hitchcock 1841, p. 494, pl. 43, fig. 35.

Platypterna macrodactylotus E. Hitchcock 1845, p. 25.

Argozoum disparidigitatum E. Hitchcock 1848, p. 186, pl. 6, fig. 2; 1858, p. 82, pl. 14, fig. 2.

Lull 1904 A, p. 519.

Type, Cat. No. 37/17, Amherst collection, from Wethersfield, Conn.

Localities. — Turners Falls and Chicopee, Mass.; Wethersfield, Conn.

Specific Characters. — Pes: Length of digit II, 76 mm.; of III, 127 mm.; IV, 90 mm.; between lateral tips, 76 mm.; length of foot, 140 mm. Divarication of digits II and III, 18° to 30°; III and IV, 20° to 25°; II and IV, 40° to 55°.

Length of the step, 380 mm. Width of trackway, 100 mm.

Argoides redfieldii E. Hitchcock

Ornithoidichnites redfieldii E. Hitchcock 1844, p. 304, pl. 3, fig. 1.

Argoides redfieldianus E. Hitchcock 1845, p. 24.

Argozoum redfieldianum E. Hitchcock 1848, p. 185, pl. 6, fig. 1; 1858, p. 81, pl. 14, fig. 1.

Argoides redfieldianus Lull 1904 A, p. 519.

Type, Cat. Nos. 14/2, 14/3 and 14/9, Amherst collection, on hard gray thick-bedded sandstone from Chicopee Falls, Mass., the only known locality.

"This track agrees in length and divarication of digits with that of *Eubrontes divaricatus,* and is undoubtedly [?] synonymous with that species" (Lull).

Genus **Plectropterna** E. Hitchcock

Plectropus E. Hitchcock 1845, p. 24 (in part); 1848, p. 198 (in part).

E. Hitchcock 1858, p. 108 (in part), for *Plectropus,* preoccupied.

Tarsoplectrus Lull 1904 A, p. 519.

Generic Characters.—"Bipedal, tetradactyl, plantigrade, heel narrow, tapering backward, not always wholly impressing. Limbs long; trackway narrow. No [generally without] phalangeal pads nor distinct claws" (Lull).

This genus as now restricted contains but four species, *P. minitans, P. angusta,* and *P. lineans* E. Hitchcock, and *P. elegans* C. H. Hitchcock, *P. minitans* being the type species. In 1904 I considered *P. minitans* a synonym for *Anomœpus intermedius,* and therefore proposed the name *Tarsoplectrus* for the two remaining species. I am not now sufficiently convinced of this synonymy and prefer to let the old name, *Plectropterna,* stand.

Plectropterna minitans (E. Hitchcock)

Sauroidichnites minitans E. Hitchcock 1841, p. 481, pl. 33, fig. 11.

Plectropus minitans and *longipes* E. Hitchcock 1845, p. 24; 1848, p. 198, pl. 9, figs. 2, 3; pl. 10, figs. 1-3.

E. Hitchcock 1858, p. 108, pl. 18, fig. 2; pl. 19, figs. 10-12.

Anomœpus intermedius Lull 1904 A, pp. 501, 520.

Type, Cat. No. 34/35, Amherst collection, from the north bank below Turners Falls, Mass.

Specific Characters. — Pes: Length of digit I, 37 mm.; II, 76 mm.; III, 120 mm.; IV, 86 mm.; heel, 109 mm.; foot, 230 mm. Distance between lateral tips, 101.5 mm. Divarication of digits II and III, 38°; III and IV, 37°; II and IV, 75°.

Length of step, 405 mm. Width of trackway, 228 mm.

Localities. — North bank below Turners Falls, Turners Falls, Field's orchard in Gill, Chicopee Falls, and near Cabotville, Mass.; Wethersfield Cove and Wethersfield, Conn.

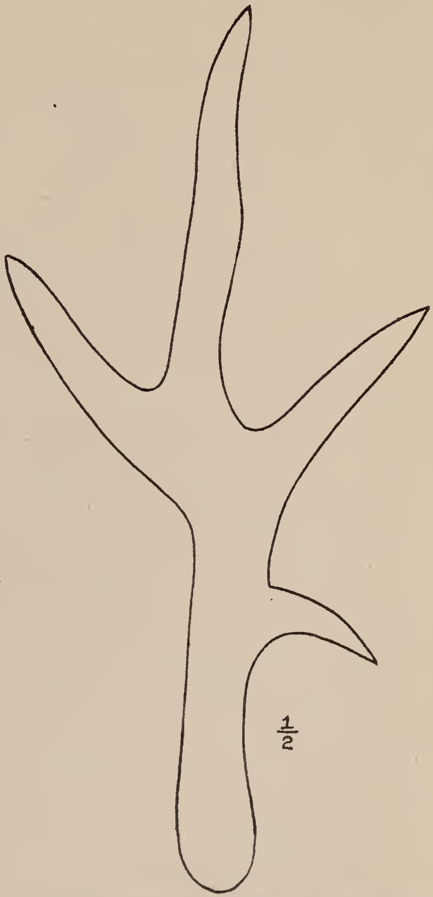


Fig. 86.—*Plectropterna minitans.* One-half nat. size. Original.

Plectropterna angusta E. Hitchcock

E. Hitchcock 1858, p. 110, pl. 18, fig. 4; pl. 36, fig. 3.

Tarsoplectrus angustus Lull 1904 A, p. 520.

Type specimen, Cat. No. 33/39, Amherst collection, from Turners Falls, Mass.

Specific Characters. — Pes: Length of digit I, 18 mm.; II, 51 mm.; III, 71 mm.; IV, 46 mm.; between lateral tips, 40 mm. Length of foot, 110 mm. Divarication of digits I and II, 95°; II and III, 22°; III and IV, 25°; II and IV, 47°.

Length of step, 305 mm. Width of trackway, 68 mm. Toes slightly curved. Hallux strongly recurved, arising about the mid-length of the heel.

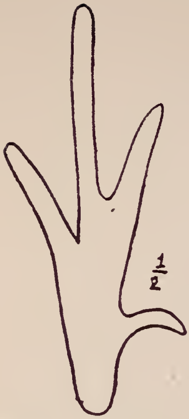


FIG. 87.—*Plectropterna angusta*. One-half nat. size. After Hitchcock.

Localities. — Lily Pond, Turners Falls, Mass.

Plectropterna elegans C. H. Hitchcock

C. H. Hitchcock 1889, pp. 122, 125.

Tarsoplectrus elegans Lull 1904 A, p. 520.

Type specimens, Cat. Nos. 53, 91, and 242, Mount Holyoke collection, from Wethersfield, Conn., the only known locality.

Specific Characters. — Pes: Length of digit I, 23 mm.; II, 26 to 45 mm.; III, 51 to 76 mm.; IV, 38 to 45 mm.; entire foot, 127 to 132 mm.; distance between lateral tips, 50 to 60 mm. Divarication of digits II and III, 30°; III and IV, 40°; II and IV, 70°.

Length of step, 457 to 533 mm. Width of trackway, 77 mm.

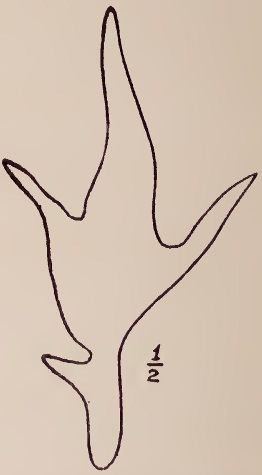


FIG. 88.—*Plectropterna elegans*. One-half nat. size. Original.

Plectropterna lineans E. Hitchcock

E. Hitchcock 1858, p. 110, pl. 18, fig. 5.

?*Harpedactylus tenuissimus* Lull 1904 A, p. 527.

Type specimen, Cat. No. 36/42, Amherst collection, on red shale from Wethersfield, Conn.

Specific Characters. — Manus: Tetradactylous; toes all curve inward. Length of hand, 25 mm.; its breadth, 20 mm.

Pes: Length of digit II, 30 mm.; III, 48 mm.; IV, 28 mm.; of heel, 18 mm.; of foot, 65 mm.; between lateral tips, 28 mm. Divarication of digits II and III, 25°; III and IV, 42°; II and IV, 67°.

Length of step, 255 mm. Width of trackway, 35 mm.

Localities. — Lily Pond, Turners Falls, Mass.; and Wethersfield, Conn.

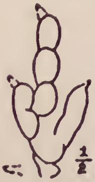


FIG. 89.—*Plectropterna lineans*. One-half nat. size. Original.

Genus **Polemarchus** E. Hitchcock

E. Hitchcock 1845, p. 24; 1848, p. 197; 1858, p. 107.

Lull 1904 A, p. 520.

Generic Characters. — Bipedal, tetradactyl, plantigrade, with broad heel and a large, half-rotated hallux. Toes slender in the track, but the latter, which is impressed upon shale, has doubtless caved in to some extent. No phalangeal pads nor claws are in evidence.

" Except for the presence of the hallux this form most nearly approximates *Platypterna*. There is but one extremely rare species: *Polemarchus gigas* [*polemarchius*] " (Lull).

Polemarchus polemarchius (E. Hitchcock)

Sauroidichnites polemarchius E. Hitchcock 1841, p. 483, pl. 35, fig. 17.

Polemarchus gigas E. Hitchcock 1845, p. 24; 1848, p. 197, pl. 9, fig. 1; 1858, p. 107, pl. 18, fig. 1; pl. 59, fig. 3.

Polemarchus gigas Lull 1904 A, p. 520.

Type specimens, Cat. Nos. 26/15, 26/16, and 26/17, Amherst collection, in slightly calcareous shale, the first two from Chicopee Falls, the last from near Cabotville, Mass. No other localities are known.

Specific Characters. — Pes: Length of digit I, 64 mm.; II, 217 mm.; III, 285 mm.; IV, 213 mm.; of heel, 97 mm.; of foot, 376 mm. Width of heel, 100 mm.; distance between the lateral toes, 165 to 222 mm. Divarication of digits I and II, 61°; II and III, 20°; III and IV, 25°; II and IV, 45°.

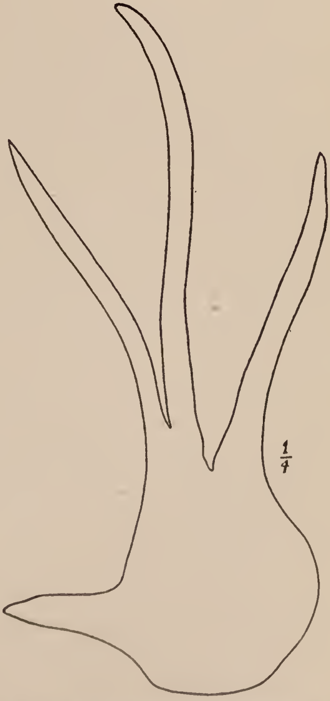


Fig. 90.— *Polemarchus polemarchius.* One-fourth nat. size. After Hitchcock.

Length of step, 1,224 mm. Width of trackway, ?350 mm. Digit I is straight, the others curve inward.

Genus **Plesiornis** E. Hitchcock

E. Hitchcock 1858, p. 102.

Lull 1904 A, p. 521.

Generic Characters. — " Bipedal or ?quadrupedal, digitigrade, tridactyl [or tetradactyl] forms, digits terminated by blunt or pellet-like claws. Small forms of doubtful affinity " (Lull).

Plesiornis pilulatus E. Hitchcock

E. Hitchcock 1858, p. 103, pl. 17, fig. 8; pl. 36, fig. 4.

Lull 1904 A, p. 521.

Type, Cat. No. 13/1, Amherst collection, on gray sandstone, from Turners Falls, Mass.

Specific Characters. — Manus: Length of digit II, 23 mm.; III, 35 mm.; IV, 23 mm. Divarication of digits II and III, 42°; III and IV, 37°; II and IV, 79°.

Pes; Length of digit II, 33 mm.; III, 42 mm.; IV, 38 mm.; foot, 53 mm.; between lateral tips, 38 mm. Divarication of digits II and III, 35°; III and IV, 35°; II and IV, 70°.

Length of step, 183 mm. Width of trackway, 50 mm.

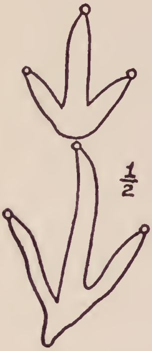


Fig. 91.—*Plesiorni pilulatus.* One-half nat. size. After Hitchcock.

" The foot is quite similar to that of *Grallator,* except for the form of the claw and the occasional presence of a spur-like process on the inner side of the foot " (Lull).

Localities. — Lily Pond, ferry above Turners Falls, and Turners Falls, Mass.

Genus **Sillimanius** E. Hitchcock

E. Hitchcock 1845, p. 24.

Ornithopus E. Hitchcock 1848, p. 191; 1858, p. 87.

Lull 1904 A, p. 522.

Generic Characters. — " Bipedal, tetradactylous, hallux rotated so as to be in line with the fourth digit. Digitigrade to semiplantigrade " (Lull).

Sillimanius tetradactylus E. Hitchcock

Ornithichnites tetradactylus E. Hitchcock 1836, p. 323, fig.

Ornithoidichnites tetradactylus E. Hitchcock 1841, p. 497, pl. 46, fig. 42.

E. Hitchcock 1845, p. 24.

Ornithopus gallinaceus E. Hitchcock 1848, p. 192, pl. 8, fig. 1; 1858, p. 87, pl. 14, fig. 10; pl. 58, fig. 1.

Lull 1904 A, p. 522.

Type specimen, Cat. No. 32/41, Amherst collection, on red shale from Wethersfield, Conn.

Specific Characters. — Pes; Length of digit I, 43 mm.; II, 43 mm.; III, 76 mm.; IV, 51 mm.; of the foot impression, 97 mm.; distance between lateral tips, 69 mm. Divarication of digits I and II, 110°; II and III, 35°; III and IV, 45°; II and IV, 80°.

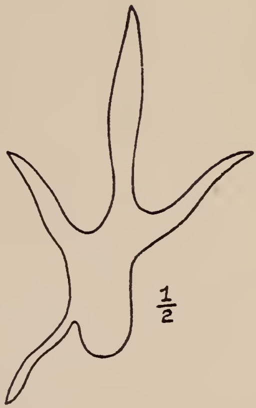


FIG. 92.— *Sillimanius tetradactylus.* One-half nat. size. Original.

Length of step, 178 mm. Width of trackway, 64 mm.

Localities.— Turners Falls, Horse Race, and near Cabotville, Mass.; Wethersfield Cove and Wethersfield, Conn.

Sillimanius gracilior E. Hitchcock.

Ornithoidichnites gracilior E. Hitchcock 1841, p. 498, pl. 46, fig. 43.

E. Hitchcock 1845, p. 24.

Ornithopus gracilior E. Hitchcock 1848, p. 193, pl. 8, fig. 2; 1858, p. 88, pl. 14, fig. 11; pl. 58, fig. 7.

Lull 1904 A, p. 523.

Type specimen, Cat. No. 31/75, Amherst collection, on red shale from Wethersfield, Conn.

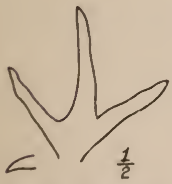


FIG. 93.—*Sillimanius gracilior.* One-half nat. size. After Hitchcock.

Specific Characters. — Pes: Length of digit I, 10 mm.; II, 21 mm.; III, 32 mm.; IV, 23 mm.; distance between lateral tips, 43 mm.; length of the foot impression, 43 mm. Divarication of digits I and II, 85°; II and III, 35°; III and IV, 52°.

Length of step, 153 mm. Width of trackway, 115 mm. Foot digitigrade.

Localities. — Turners Falls, north bank below Turners Falls, Mass.; Wethersfield Cove, Wethersfield, Conn.

Genus **Steropoides** E. Hitchcock

E. Hitchcock 1845, p. 24.

Steropezoum E. Hitchcock 1848, p. 182.

Tridentipes E. Hitchcock 1858, p. 88 (to replace *Steropezoum*).

Lull 1904 A, p. 523.

Generic Characters. — "Bipedal, tetradactyl, subdigitigrade to semiplantigrade. Tarsus sloping upward so that the impression often ends in ridges and furrows. The hallux is rotated backward so as to be in line with digit IV" (Lull).

Steropoides diversus (E. Hitchcock)

Ornithichnites diversus E. Hitchcock 1836, fig. 22.

Ornithoidichnites elegans E. Hitchcock 1841, p. 491, pl. 41, figs. 28, 29.

Ornithoidichnites elegantior E. Hitchcock 1841, p. 493, pl. 42, fig. 30.

Steropoides elegans E. Hitchcock 1845, p. 24.

Steropoides elegantior E. Hitchcock 1845, p. 24.

Steropezoum elegans E. Hitchcock 1848, p. 183, pl. 5, fig. 2.

Steropezoum elegantius E. Hitchcock 1848, p. 184, pl. 5, fig. 3.

Tridentipes elegans E. Hitchcock 1858, p. 90, pl. 15, fig. 2; pl. 45, fig. 6; pl. 52, figs. 8, 11.

Steropoides elegans Lull 1904 A, p. 523.

Type specimen, Cat. No. 26/21, Amherst collection, on red shale from Turners Falls, Mass.

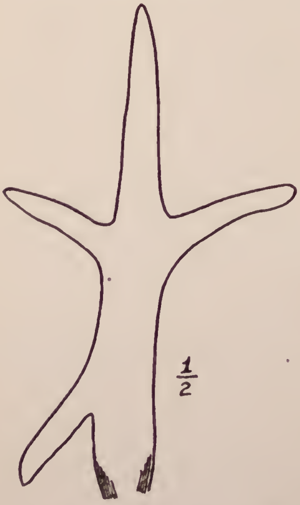


FIG. 94.—*Steropoides diversus*. One-half nat. size. After Hitchcock.

Specific Characters. — Pes: Length of digit I, 46 mm.; II, 46 mm.; III, 71 mm.; IV, 56 mm.; between lateral tips, 89 mm.; length of heel impression, 64 mm.; its breadth, 13 mm. Length of foot, 135 mm. Divarication of digits I and II, 75°; II and III, 65°; III and IV, 65°; II and IV, 125°.

Length of step, 250 to 500 mm. Width of trackway, 178 mm.

Localities. — Horse Race, Lily Pond, Turners Falls, Montague City, Mass.; Wethersfield, Conn.

Steropoides ingens E. Hitchcock

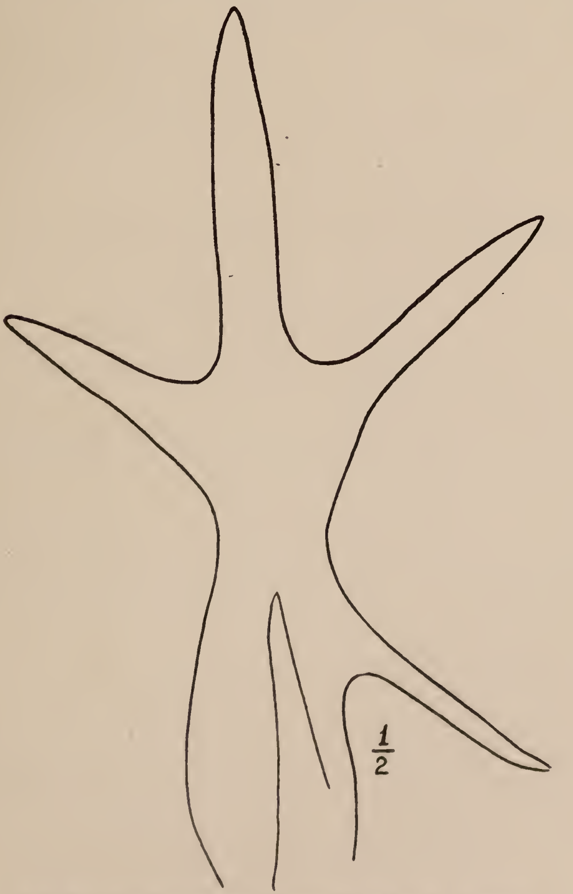


Fig. 95.— *Steropoides ingens.* One-half nat. size. Original.

Ornithichnites ingens E. Hitchcock 1836, p. 320, fig.
Ornithoidichnites ingens 1841, p. 490, pl. 40, fig. 27.
E. Hitchcock 1845, p. 24.
Sillimanius adamsanus E. Hitchcock 1845, p. 24.
Ornithoidichnites danæ E. Hitchcock 1847, p. 306, pl. 4, fig. 5.
Steropezoum ingens E. Hitchcock 1848, p. 182, pl. 5, fig. 1.
Ornithopus adamsanus E. Hitchcock 1848, p. 191, pl. 7, fig. 5.
Tridentipes ingens E. Hitchcock 1858, p. 89, pl. 15, fig. 1.
Lull 1904 A, p. 524.

Type specimen, Cat. No. 16/12, Amherst collection, on gray micaceous sandstone, from Gill, Mass.

Specific Characters. — Pes: Length of digit I, 127 mm.; II, 203 mm.; III, 242 mm.; IV, 145 mm.; between lateral tips, 282 mm.; heel impression, 230 mm.; foot, 460 mm. Divarication of digits I and II, 80°; II and III, 50°; III and IV, 58°; II and IV, 107°.

Length of step, 1,020 to 2,020 mm.

Localities. — Horse Race, Gill, Mass.; Whitehall, N. J.

Steropoides infelix Hay

Tridentipes elegantior E. Hitchcock 1858, p. 90, pl. 15, fig. 3; pl. 45, fig. 1 (not *Steropezoum elegantius* of 1848).

Hay 1902, p. 552 (to replace *elegantior,* a name already used within the genus).

Lull 1904 A, p. 524.

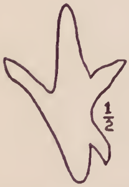


FIG. 96. — *Steropoides infelix.* One-half nat. size. After Hitchcock.

Type specimen, Cat. No. 19/9, Amherst collection, on reddish shale from Turners Falls, Mass.

Specific Characters.— Pes: Length of digit I, 10 mm.; II, 15 mm.; III, 29 mm.; IV, 23 mm.; between lateral tips, 28 mm. Length of heel impression, 18 mm.; of the foot, 45 mm. Divarication of digits I and II, 108°; II and III, 32°; III and IV, 44°; II and IV, 75°.

Length of step, 135 mm. Width of trackway, 45 mm.

Localities. — Lily Pond, Turners Falls, Mass.; Wethersfield, Conn.

Steropoides divaricatus (E. Hitchcock)

Ornithoidichnites divaricatus E. Hitchcock 1841, p. 495, pl. 44, figs. 36, 37.

Ornithopus loripes E. Hitchcock 1848, p. 193, pl. 8, fig. 3.

Tridentipes insignis E. Hitchcock 1858, p. 91, pl. 15, fig. 4; pl. 45, fig. 3; pl. 47, fig. 2.

Steropoides loripes Lull 1904 A, p. 525.

Type specimens, Cat. Nos. 1/4 and 5/11, Amherst collection, on micaceous sandstone, from near Montague, Mass.

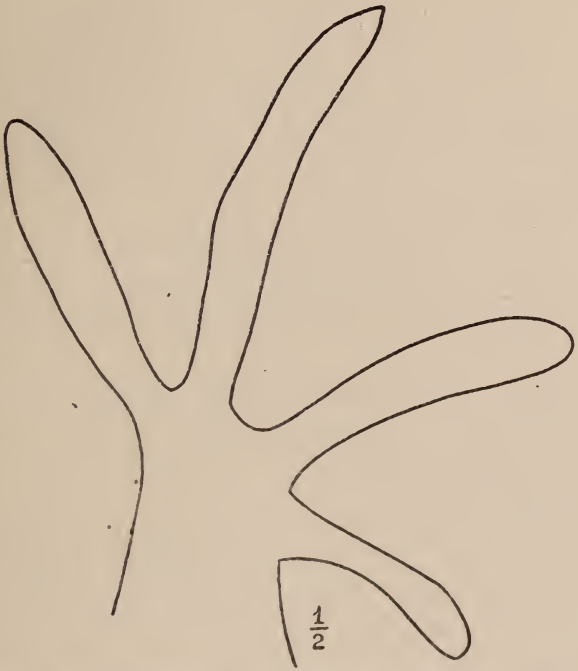


FIG. 97.—*Steropoides divaricatus*. One-half nat. size. After Hitchcock.

Specific Characters. — Pes: Length of digit I, 81 mm.; II, 109 mm.; III, 135 mm.; IV, 109 mm.; between lateral tips, 160 mm.; of heel impression, variable up to 50 mm.; of foot, 152 to 178 mm. Divarication of digits I and II, 55°; II and III, 45°; III and IV, 50°; II and IV, 95°.

Localities. — Horse Race, Turners Falls, Montague City and South Hadley, Mass.

Steropoides uncus (E. Hitchcock)

Tridentipes uncus E. Hitchcock 1858, p. 91, pl. 15, fig. 5; pl. 46, fig. 1.

Lull 1904 A, p. 525.

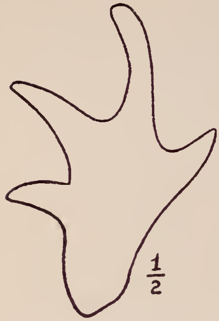


FIG. 98.—*Steropoides uncus*. One-half nat. size. After Hitchcock.

Type specimen, Cat. No. 6/1, Amherst collection, from Turners Falls, Mass.

Specific Characters.— Pes: Length of digit I, 28 mm.; II, 43 mm.; III, 56 mm.; IV, 36 mm.; between lateral tips, 56 mm.; of heel, 28 mm.; of the foot, 82 mm. Divarication of digits I and II, 22°; II and III, 48°; III and IV, 44°; II and IV, 90°.

Length of step, 215 to 227 mm. Width of trackway, 155 mm.

"*S. uncus* differs markedly from the other members of the genus in the short step and wide trackway, and also in the position of the hallux which is only semirotated" (Lull).

Localities. — Lily Pond and Turners Falls, Mass.

Genus **Lagunculapes** E. Hitchcock

E. Hitchcock 1858, p. 132.

Lull 1904 A, p. 525.

Generic Characters. — "Bipedal, digitigrade, tetradactyl, with the clawless digits widely radiating and more or less flask- or club-shaped, dilating toward their tips" (Lull).

Lagunculapes latus E. Hitchcock

E. Hitchcock 1858, p. 132, pl. 24, fig. 1; pl. 45, fig. 4.

Lull 1904 A, p. 525.

Type specimen, Cat. No. 33/29, Amherst collection, on gray shale from Turners Falls.

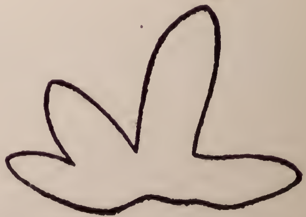


FIG. 99.—*Lagunculapes latus*. Nat. size. Original.

Specific Characters. — Pes: Length of digit I, 13 mm.; II, 14 mm.; III, 20 mm.; IV, 15 mm.; of the foot, 22 mm.; width of the foot, 32 mm. Divarication of digits I and II, 50°, II and III, 70°; III and IV, 65°; I and IV, 180°.

Length of step, 76 mm. Width of trackway, 76 mm.

Localities. — Turners Falls, canal at Montague, Mass.

Forms Occasionally Quadrupedal

Genus **Xiphopeza** E. Hitchcock

E. Hitchcock 1848, p. 239; 1858, p. 113.

Lull 1904 A, p. 526.

Generic Characters. — "Quadrupedal, possibly not habitually so; plantigrade; the tetradactylous pes much larger than the manus, which, in the known specimens, impresses but three digits" (Lull).

Xiphopeza triplex E. Hitchcock

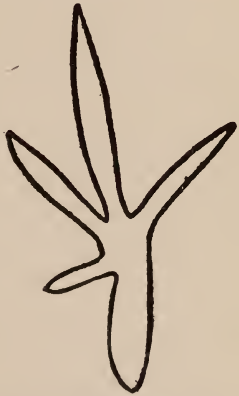


Fig. 100.—*Xiphopeza triplex* Nat. size. Original.

E. Hitchcock 1848, p. 239, pl. 15, fig. 8; 1858, p. 113, pl. 20, fig. 6; pl. 52, figs. 2, 4, 6.

Lull 1904 A, p. 526.

Type specimen, Cat. No. 41/26, Amherst collection, on gray shale from Turners Falls, Mass.

Specific Characters. — Manus: But three digits impressing; about 10 mm. in length.

Pes: Length of digit I, 13 mm.; II, 20 mm.; III, 38 mm.; IV, 28 mm.; of heel, 30 mm.; of foot, 66 mm.; between lateral tips, 38 mm.; breadth of heel, 12 mm. Divarication of digits I and II, 90°; II and III, 40°; III and IV, 50°.

Length of step, 102 mm. Width of trackway, 115 mm.

Localities. — Field's orchard in Gill, Turners Falls, north bank below Turners Falls, Mass.

Genus **Tarsodactylus** E. Hitchcock

E. Hitchcock 1858, p. 98.

Lull 1904 A, p. 526.

Generic Characters. — "Quadrupedal, digitigrade; manus pentadactylous, pes tetradactylous with broad digits and somewhat acuminate claws. Tail trace present" (Lull).

Tarsodactylus caudatus E. Hitchcock

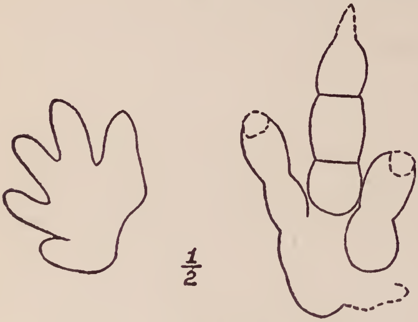


Fig. 101.— *Tarsodactylus caudatus.* One-half nat. size. Original.

E. Hitchcock 1858, p. 99, pl. 17, fig. 4; pl. 36, fig. 2.

Lull 1904 A, p. 527.

Type specimen, Cat. No. 42/5, Amherst collection, on shale from Turners Falls, Mass.

Specific Characters. — Manus: Length of digit I, 14 mm.; II, 19 mm.; III, 18 mm.; IV, 11.5 mm.; V, 9 mm.; of entire manus, 46 mm.; its breadth, 37 mm. Divarication of digits I and II, 24°; II and III, 21°; III and IV, 21°; IV and V, 15°; I and V, 81°.

Pes: Length of digit II, 32 mm.; III, 54 mm.; IV to rear of heel, 54 mm.; of the foot, 80 mm.; between lateral tips, 46 mm. Divarication of digits I and II, 74°; II and III, 18°; III and IV, 22°; I and IV, 114°.

Length of step, about 200 mm. Ratio of foot to stride as 1 : 2½.

Localities. — Lily Pond and Turners Falls, Mass.

Tarsodactylus expansus C. H. Hitchcock

C. H. Hitchcock 1866, p. 301.

Lull 1904, p. 527.

Type specimen, Dartmouth College collection, from near Greenfield, Mass., the only recorded locality.

Specific Characters. — Manus: Length of digit I, 12 mm.; II, 20 mm.; III, 19 mm.; IV, 15 mm.; V, 9. 5 mm.; between lateral tips, 25 mm. Divarication of digits I and II, 30°; II and III, 20°; III and IV, 25°; IV and V, 25° to 30°; I and V, 100°.

Pes: Length of digit II, 25 mm.; III, 37 mm.; IV, 28 mm.; hallux claw, 5 mm.; its distance from the foot, 10 mm.; between lateral tips, 38 mm. Length of foot, 43 mm. Divarication of digits II and III, 25°; III and IV, 50°; II and IV, 75° to 80°.

Length of step, 127 to 178 mm. Width of trackway, 140 mm. Caudal trace slight.

Genus **Harpedactylus** E. Hitchcock

E. Hitchcock 1845, p. 24; 1848, p. 206; 1858, p. 112.

Lull 1904 A, p. 527.

Generic Characters. — "Quadrupedal, tetradactylous, plantigrade; heel long, digits sometimes curved inward, sickle-like. This genus represents a group of mud tracks, at least two species of which seem referable to Anomœpodoid forms, while the third, *H. crassus,* is not so typical" (Lull).

Harpedactylus tenuissimus E. Hitchcock

Sauroidichnites tenuissimus E. Hitchcock 1841, p. 482, pl. 34, fig. 13.

E. Hitchcock 1845, p. 24.

Harpedactylus gracilis E. Hitchcock 1848, p. 206, pl. 14, fig. 2; 1858, p. 112, pl. 20, fig. 4; pl. 52, fig. 5.

Lull 1904 A, p. 527.

Type specimen, Cat. No. 27/18, Amherst collection, from Turners Falls, Mass.

Specific Characters. — Manus: Imperfectly known. Length of hand, 28 mm.; of "heel," 6 mm.

Pes: Length of digit I, 23 mm.; II, 33 mm.; III, 53 mm.; IV, 40 mm.; of heel, 55 mm.; its breadth, 5 mm. Length of foot, 90 mm. Divarication of digits II and III, 50°; III and IV, 50°.

Length of step, 90 mm. Width of trackway, 125 mm.

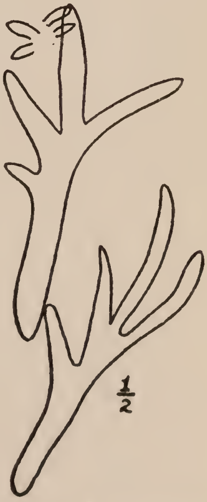
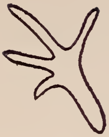


Fig. 102.—*Harpedactylus tenuissimus.* One-half nat. size. After Hitchcock.

Localities. — Turners Falls, north bank below Turners Falls, Mass.; Wethersfield, Conn.



Harpedactylus gracilior E. Hitchcock

E. Hitchcock 1865, p. 12, pl. 3, fig. 2.

Lull 1904 A, p. 528.

Type specimens, Cat. Nos. 47/52 and 55/1, Amherst collection, from Turners Falls, Mass.

Specific Characters.— Manus: Unknown. Pes: Length of digit I, 7.5 mm.; II, 18 mm.; III, 23 mm.; IV, 18 mm.; of the heel, 19 mm.; of the foot, 41 mm. Divarication of digits I and II, 52°; II and III, 34°; III and IV, 72°; I and IV, 158°.

Length of step, 90 mm.

Localities. — Lily Pond, north bank below Turners Falls, Mass.

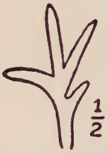


FIG. 103.—*Harpedactylus gracilior.* One-half nat. size. After Hitchcock.

Harpedactylus crassus E. Hitchcock

E. Hitchcock 1865, p. 12, pl. 3, fig. 1.

Lull 1904 A, p. 528.

Type specimen, Cat. No. 47/53, Amherst collection, on gray shale. Locality unrecorded.

This species is based upon a ground-down track showing both manus and pes. Characterless and of doubtful affinity.

Forms Habitually Quadrupedal

Genus **Corvipes** E. Hitchcock

E. Hitchcock 1858, p. 98.

Lull 1904 A, p. 509.

Generic Characters. — "Quadrupedal. Pes tridactylous, ornithoid, digitigrade. Manus pentadactylous, digits curved. Position of print of manus a little in advance of, sometimes without, again covered in part by that of the pes. No phalangeal nor claw impressions. Tips of digits more or less acuminate" (Lull).

Corvipes lacertoideus E. Hitchcock

E. Hitchcock 1858, p. 98, pl. 17, fig. 3; pl. 35, fig. 7; pl. 47, fig. 1.

Lull 1904 A, p. 510.

Type specimen, Cat. No. 32/1, Amherst collection, on sandstone from Turners Falls, Mass.

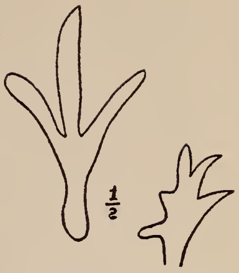


Fig. 104.—*Corvipes lacertoideus.* One-half nat. size. After Hitchcock.

Specific Characters. — Manus: Length of digit I, 10 mm.; II, 10 mm.; III, 19 mm.; IV, 20 mm.; V, 15 mm.; of the hand, 33 mm. Divarication of digits I and V, 160°.

Pes: Length of digit II, 33 mm.; III, 43 mm.; IV, 33 mm.; length of heel, 23 mm.; of foot, 66 mm. Divarication of digits II and III, 40°; III and IV, 35°; II and IV, 75°.

Length of step, 43 to 68 mm.

Localities. — Horse Race, Lily Pond, Turners Falls, Field's orchard in Gill, Mass.; Wethersfield, Conn.

Genus **Ancyropus** E. Hitchcock

E. Hitchcock 1845, p. 24; 1848, p. 242; 1858, p. 138.

Lull 1904 A, p. 528.

Generic Characters. — " Quadrupedal, plantigrade. Pes tetra- or pentadactylous, hallux semirotated, the other digits turned outward very strongly. Manus tetradactylous, digits as in pes, but much slenderer in proportion to its length. No pad nor claw impressions are preserved" (Lull).

In President Hitchcock's opinion the creatures which made these tracks were chelonian. The " Chélodine de la Nouvelle Hollande" figured in Duméril et Bibron, Atlas d'Erpétologie, p. 21, fig. 2, suggests a track-maker not unlike this genus.

Ancyropus heteroclitus E. Hitchcock

Sauroidichnites heteroclitus and *jacksoni* E. Hitchcock 1841, p. 478, pl. 30, figs. 2, 3.

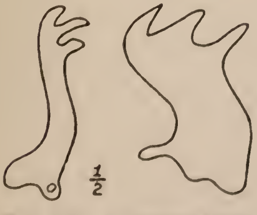


Fig. 105.—*Ancyropus heteroclitus.* One-half nat. size. After Hitchcock.

E. Hitchcock 1845, p. 24; 1848, p. 243, pl. 15, figs. 3-5; 1858, p. 139, pl. 25, figs. 3, 4; pl. 53, figs. 1, 2.

Ancyropus jacksonianus E. Hitchcock 1845, p. 24.

Lull 1904 A, p. 529.

Type, Cat. No. 27/7, Amherst collection, on gray shale from Wethersfield, Conn.

Specific Characters. — Manus: Length, 51 mm.; average length of digits, 7 to 8 mm.; breadth of palm, 7 mm.

Pes: Length of foot, 51 mm.; breadth across digits, 33 mm., across heel, 20 mm. Average length of digits, about 10 mm.

Length of step, 63 mm. Width of trackway, 165 mm.

The shortness of limbs and width of trackway as well as the character of the feet are turtle-like, hence this form seems to be included in that order.

Localities. — North bank below Turners Falls, ?Moody's corner, Mass.

Genus **Chelonoides** E. Hitchcock

E. Hitchcock 1858, p. 140.

Lull 1904 A, p. 529.

Generic Characters. — " Quadrupedal; pes tridactylous, digitigrade, smaller than the plantigrade, pentadactyl manus. No pads nor claws. Limbs long; body wide " (Lull).

What Hitchcock calls the manus is certainly much more pes-like; but its impression always comes in front of the so-called pes and I have allowed it to stand. The footprint does not, however, seem at all turtle-like, as the limbs are too long and the feet unlike those of modern Chelonians, the width of body as evidenced by that of the trackway being the only chelonoid character.

Chelonoides incedens E. Hitchcock

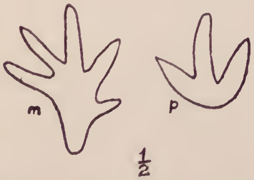


FIG. 106.—*Chelonoides incedens.* One-half nat. size. After Hitchcock. *m*, Manus; *p*, pes.

E. Hitchcock 1858, p. 140, pl. 31, fig. 3.

Lull 1904 A, p. 529.

Type specimen, Cat. No. 6/1, Amherst collection, from the Lily Pond, Turners Falls, Mass., the only recorded locality.

Specific Characters. — Manus: Length of digit I, 10 mm.; II, 18 mm.; III, 23 mm.; IV, 20 mm.; V, 20 mm.; of the "heel," 28 mm.; of entire impression, 43 mm. Divarication of digits II and V, 100°.

Pes: Length of digit II, 17 mm.; III, 20 mm.; IV, 17 mm.; of the foot, 26 mm. Divarication of digits II and IV, 80.°.

Length of stride, 180 mm. Width of trackway, 165 mm.

Genus **Amblypus** E. Hitchcock

E. Hitchcock 1858, p. 143.

Lull 1904 A, p. 530.

Generic Characters.— Manus: Unknown. Pes: Plantigrade, tridactylous, with the digits curving inward.

A curious feature is that in each of several specimens preserved in the Amherst collection the *right* hind foot only is impressed, while an isolated track, Cat. No. 2134, in the Yale collection, which I refer to this genus, shows only the left.

" Hitchcock thinks the animal a Chelonian as the foot ' approximates to that of some tortoises ' " (Lull).

Amblypus dextratus E. Hitchcock

E. Hitchcock 1858, p. 143, pl. 25, fig. 7; pl. 48, fig. 5.

Lull 1904 A, p. 530.

Type specimen, Cat. No. 34/27, Amherst collection, on gray shale from Turners Falls, Mass., the only known locality.

Specific Characters. — Pes: Length of foot, 25 mm.; breadth, about 15 mm. Digital impressions not separated. Length of step, 100 to 115 mm.

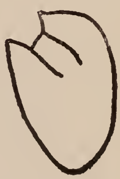


FIG. 107.—*Amblypus dextratus.* Nat. size. After Hitchcock.

Genus **Helcura** E. Hitchcock

E. Hitchcock 1848, p. 244; 1858, p. 140.

Lull 1904 A, p. 530.

Generic Characters. — " Quadrupedal; tail and toes often dragging on the ground " (Hitchcock). Broad body trace.

" These traces give absolutely no data concerning the form and structure of the feet. Hitchcock compares the markings to those left by living land tortoises and hence classes them provisionally with the Chelonia " (Lull).

Helcura anguinea E. Hitchcock

E. Hitchcock 1858, p. 141, pl. 36, fig. 9.

Lull 1904 A, p. 530.

Type, Cat. No. 40/8, of the Amherst collection, on gray shale, from Turners Falls, Mass.

Specific Characters.— Length of stride of same foot, 125 to 150 mm. Width of trackway, 75 mm.

Locality. — North bank below Turners Falls, Mass.

Helcura littoralis E. Hitchcock

E. Hitchcock 1848, p. 244, pl. 15, fig. 1; pl. 23, fig. 3.

Helcura caudata E. Hitchcock 1858, p. 140, pl. 37, fig. 3; pl. 40, fig. 1.

Lull 1904 A, p. 531.

Type, Cat. No. 26/10, Amherst collection, from Turners Falls, Mass.

Specific Characters.— Length of stride, 150 mm. Width of trackway, 125 mm.

Helcura surgens E. Hitchcock

E. Hitchcock 1858, p. 141, pl. 36, fig. 10.

Lull 1904 A, p. 531.

Type, Cat. No. 19/8, Amherst collection, from Turners Falls, Mass. Not otherwise recorded.

Specific Characters. — Width of trackway, 125 to 150 mm. No tail trace nor footprints.

Genus **Eupalamopus** Hay

Hay 1902, p. 544 (name given as a substitute for *Palamopus* E. Hitchcock 1848, p. 217, preoccupied by E. Hitchcock in 1845).

Lull 1904 A, p. 531.

Generic Characters. — " ?Quadrupedal. Pes palmated, tetradactylous, all toes directed forward. Heel stout, bent outward. Manus not well known, about one third the length of the pes" (Lull).

Eupalamopus dananus (E. Hitchcock)

Palamopus dananus E. Hitchcock 1848, p. 217, pl. 11, figs. 1, 2.

Palamopus clarki E. Hitchcock 1858, p. 127, pl. 23, fig. 2; pl. 44, fig. 2.

Lull 1904 A, p. 531.

Type specimen, Cat. No. 12/1, Amherst collection, from the east face of Mount Tom, Mass. (posterior shales). No other recorded locality or specimen.

Specific Characters. — Manus: Length, 90 mm.; breadth, 38 mm.; characters highly obscure.

Pes: Length of digit I, 137 mm.; II, 165 mm.; III, 217 mm.; IV, 153 mm.; all measured from the extremity of the heel. Distance between lateral tips, 120 mm. Length of foot, 217 mm. Divarication of digits I and II, 25°; II and III, 30°; III and IV, 15°.

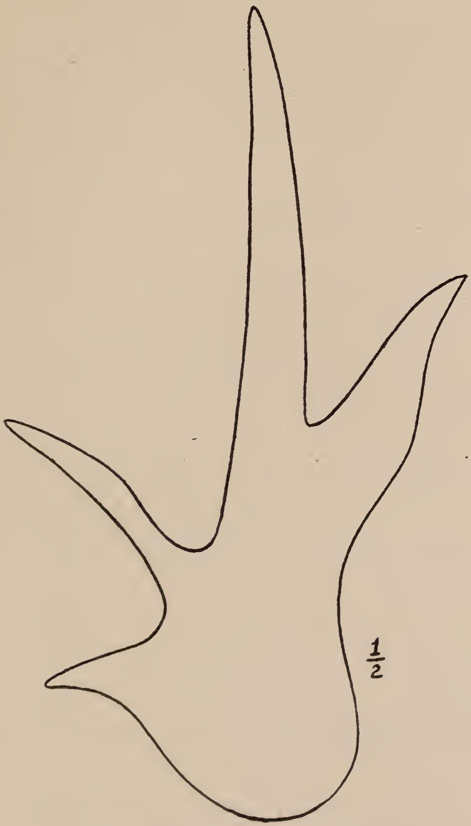


FIG. 108.—*Eupalamopus dananus.*
One-half nat. size. Original.

Length of step, 535 mm. Width of trackway, 127 mm.

The largest quadrupedal track, if such it is, in the Connecticut valley fauna.

Class ?AMPHIBIA

The following footprints are more amphibian-like than any that have gone before, but represent a wide variation in the character of the animals that made them.

Genus **Palamopus** E. Hitchcock

E. Hitchcock 1845, p. 24.

Sillimanius E. Hitchcock 1845, p. 24 (in part).

Macropterna E. Hitchcock 1858, p. 128.

Lull 1904 A, p. 532.

O. P. Hay (1902, p. 548) writes: "This is not the *Palamopus* of 1848 and subsequently. The latter is here replaced by *Eupalamopus*."

Generic Characters. — "Quadrupedal; manus and pes of unequal size, the latter being from two to three times the length of the former. Feet plantigrade. Pes tetradactyl. Manus pentadactyl; no claw nor phalangeal pad impressions. Caudal trace sometimes present" (Lull).

Palamopus palmatus (E. Hitchcock)

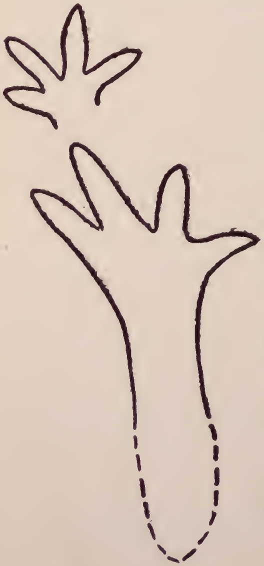


FIG. 109.—*Palamopus palmatus*. Nat. size. Original.

Sauroidichnites palmatus E. Hitchcock 1841, p. 483, pl. 34, figs. 15, 16.

Palamopus anomalus E. Hitchcock 1845, p. 24.

Macropterna recta E. Hitchcock 1848, p. 235, pl. 15, fig. 6.

Macropterna divaricans E. Hitchcock 1848, p. 237, pl. 15, fig. 7; 1858, p. 129, pl. 23, fig. 7.

Palamopus divaricans Lull 1904 A, p. 532.

Palamopus anomalus Lull 1904 A, p. 532.

Type, Cat. No. 27/3, Amherst collection, on red shale, from Turners Falls, Mass.

Specific Characters. — Manus: With five digits radiating through about 180°. Length, 23 mm.; breadth, 18 mm.

Pes: Length of digit I, 13 mm.; II, 15 mm.; III, 27 mm.; IV, 15 mm.; between lateral tips, 30 mm.; length of heel, 43 mm.; its breadth, 12 mm. Length of foot, 69 mm. Divarication of digits I and II, 20°; II and III, 30°; III and IV, 40°; I and IV, 90°.

Length of step, 84 to 178 mm. Width of trackway, 76 mm.

Localities. — Horse Race, Turners Falls, Mass.

Palamopus gracilipes (E. Hitchcock)

Macropterna gracilipes E. Hitchcock 1858, p. 129, pl. 23, fig. 6; pl. 34, fig. 1.

Lull 1904 A, p. 533.

Type specimen, Cat. No. 35/23, Amherst collection, on shale from Turners Falls, Mass.

Specific Characters. — Manus: But four digits impressing; form and divarications about those of the pes. Length, 5 mm.; breadth, 9 mm.

Pes: Length of digit I, 4 mm.; II, 7 mm.; III, 8 mm.; IV, 7 mm.; of heel, 7 mm.; of foot, 15 mm. Divarication of digits I and II, 40°; II and III, 25°; III and IV, 25°; I and IV, 90°.

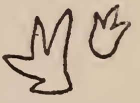


Fig. 110.—*Palamopus gracilipes.* Nat. size. After Hitchcock.

Length of step, 38 to 48 mm.

Localities. — Lily Pond and Turners Falls, Mass.

Palamopus rogersi (E. Hitchcock)

Ornithoidichnites minimus E. Hitchcock 1841, p. 496, pl. 45, fig. 41 (in part).

Ornithoidichnites rogersi E. Hitchcock 1843, p. 256, pl. 11, fig. 7.

Argoides minimus E. Hitchcock 1845, p. 24 (in part).

Sillimanius rogersianus E. Hitchcock 1845, p. 24.

Macropterna rhynchosauroidea E. Hitchcock 1848, p. 233, pl. 15, fig. 9.

Macropterna vulgaris E. Hitchcock 1858, p. 128, pl. 23, fig. 5; pl. 35, fig. 9; pl. 37, fig. 4; pl. 48, fig. 7; pl. 49, fig. 3; pl. 58, fig. 14.

Palamopus rogersianus Lull 1904 A, p. 533.

Types, Cat. Nos. 36/25 and 39/79, Amherst collection, from Turners Falls, Mass.

Specific Characters — Manus: Five digits impressing, ranging through 180°. Length, 15 mm.; breadth, 11 mm.

Pes: Length of digit I, 5 mm.; II, 9 mm.; III, 13 mm.; IV, 13 mm.; of heel, 15 mm.; of foot, 28 mm. Divarication of digits I and II, 30°; II and III, 20°; III and IV, 30°; I and IV, 80°.

Length of step, 46 mm. Width of trackway, 50 mm.

Caudal trace sinuous, not always present.

Localities. — Horse Race, Lily Pond, north bank below Turners Falls, Turners Falls, ?Field's orchard in Gill, Mass.; Wethersfield, Conn.

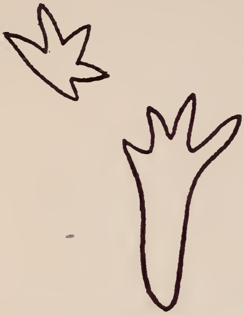


FIG. 111.— *Palamopus rogersi.* Nat. size. After Hitchcock.

Genus **Exocampe** E. Hitchcock

E. Hitchcock 1858, p. 142.

Lull 1904 A, p. 534.

Generic Characters. — "Quadrupedal. Pes tetradactylous, digitigrade, heel occasionally impressing; the three outermost digits curved outward from the line of direction. Manus pentadactylous, about one-half the length of the pes; not always impressing. Legs moderately long, as indicated by the long step and the narrow trackway" (Lull).

Exocampe arcta E. Hitchcock

E. Hitchcock 1858, p. 142, pl. 25, figs. 5, 6, 10; pl. 49, fig. 5.

Lull 1904 A, p. 534.

Type specimen, Cat. No. 35/24, Amherst collection, from Turners Falls, Mass.

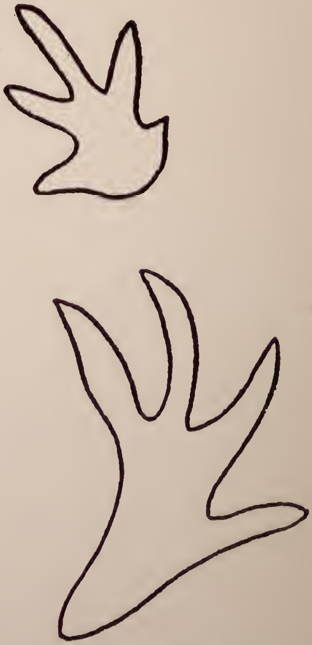


FIG. 112.— *Exocampe arcta.* Nat. size. Original.

Specific Characters. — Manus: Length of digit I, 9 mm.; II, 23 mm.;

III, 25 mm.; IV, 25 mm.; V, 13 mm. Divarication of lateral digits, 110°.

Pes: Length of digit I, 20 mm.; II, 28 mm.; III, 33 mm.; IV, 33 mm.; of heel, 20 mm.; of foot, 48 mm. Divarication of outer toes, 110°.

Length of step, 217 mm. Width of trackway, 75 mm. Digits of manus less curved than those of pes.

Localities. — Turners Falls, north bank below Turners Falls, Mass.

Exocampe ornata E. Hitchcock

E. Hitchcock 1858, p. 143, pl. 25, fig. 11; pl. 48, figs. 1, 6.

Lull 1904 A, p 534.

Type specimens, Cat. Nos. 39/69 and 41/39, Amherst collection, from Turners Falls.

Specific Characters. — Manus: Four digits directed forward and one to the rear. Divarication of the former, 130°. Length of manus, 13 mm.

Pes: Length of digit I, 6 mm.; II, 7 mm.; III, 10 mm.; IV, 8 mm. Divarication of lateral digits, 100° to 160°.

Length of step, 55 mm. Width of trackway, 25 mm.

Localities. — Lily Pond, ferry above Turners Falls, north bank below Turners Falls, Turners Falls, Mass.; Wethersfield Cove, Conn.

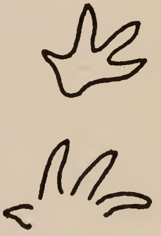


FIG. 113.—*Exocampe ornata.* Nat. size. After Hitchcock.

Exocampe minima E. Hitchcock

E. Hitchcock 1865, p. 11, pl. 18, fig. 3.

C. H. Hitchcock, in E. Hitchcock 1865, Appendix C, p. 89.

Lull 1904 A, p. 534.

Type specimen, Cat. No. 55/4, Amherst collection, from Gill, Mass.

Specific Characters. — Manus: One short hind toe and four front ones; the latter with a divarication of 138°. Digits vary in length from 4 to 5 mm.; nearly straight.

Pes: Length of digit I, 3 mm.; II, 6.5 mm.; III, 8 mm.; IV, 4.5 mm. Divarication of lateral digits, 100° to 130°. Very delicate claws sometimes impressing.

Length of step, 28 to 50 mm. Width of trackway, 38 mm.

Localities. — Field's orchard in Gill, ? Turners Falls, Mass.

Genus **Orthodactylus** E. Hitchcock

E. Hitchcock 1858, p. 113.

Lull 1904 A, p. 535.

Generic Characters. — "Quadrupedal, digitigrade. Pes with four long, straight digits, diverging but little; clawless and without phalangeal pads. Manus pentadactyl, digits ranging through 180° or more of divarication. Impression just in advance of that of the pes" (Lull).

Orthodactylus floriferus E. Hitchcock

E. Hitchcock 1858, p. 114, pl. 20, fig. 7; pl. 45, fig. 2.

Lull 1904 A, p. 535.

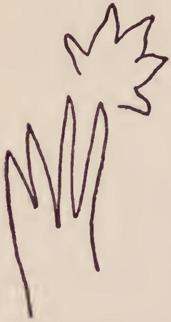


FIG. 114.— *Orthodactylus floriferus.* Nat. size. Original.

Type specimen, Cat. No. 6/1, Amherst collection, from Turners Falls, Mass.

Specific Characters. — Manus: With subequal digits, about 13 mm. in length, ranging through 180°.

Pes: Length of digit I, 15 mm.; II, 20 mm.; III, 30 mm.; IV, 18 mm.; between lateral tips, 13 mm. Divarication of digits I and II, 12.5°; II and III, 4°; III and IV, 9.5°; I and IV, 25°. The right hind foot impression only is known, and the digits seem to have been lengthened unduly in the track by the slipping of the foot.

Length of step, about 180 mm. Width of trackway, 182 mm.

Localities. — Lily Pond, Turners Falls, Mass.

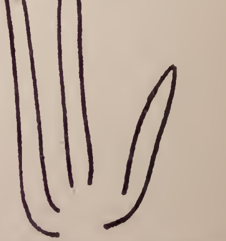


FIG. 115. — *Orthodactylus introvergens.* Nat. size. After Hitchcock.

Orthodactylus introvergens E. Hitchcock

E. Hitchcock 1858, p. 114, pl. 20, fig. 8; pl. 51, fig. 1.

Lull 1904 A, p. 535.

Specific characters. — Manus: Digits somewhat curved, about half the length of the pes.

Pes: Digits straight, very narrow, from 20 to 32 mm. in length; distance between lateral tips, 25 mm. Divarication of lateral toes, about 20°.

Length of step, 54 mm. Width of trackway, 83 mm. The axis of both manus and pes turns in toward the median line; in *O. floriferus* the reverse is true.

Localities. — Lily Pond, Turners Falls, Field's orchard in Gill, Mass.

Orthodactylus linearis E. Hitchcock

E. Hitchcock 1858, p. 115, pl. 20, fig. 9; pl. 48, fig. 4.

Lull 1904 A, p. 536.

Type specimen, Cat. No. 27/15, Amherst collection, on red shale, from Turners Falls, Mass., the only recorded locality.

Specific Characters. — Manus: Apparently similar to the pes, though much slenderer.

Pes: Digits ranging in length from 7 to 13 mm., nearly parallel, the total divergence not exceeding 20°.

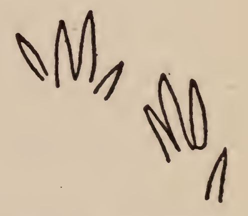


FIG. 116. — *Orthodactylus linearis.* Nat. size. After Hitchcock.

Length of step, 43 mm. Width of trackway, 38 mm.

In the type specimen feet and tail drag, which may not have been habitual.

Genus **Antipus** E. Hitchcock

E. Hitchcock 1858, p. 115.

Lull 1904 A, p. 536.

Generic Characters. — "Quadrupedal, digitigrade. Pes tetradactylous, manus pentadactylous, without claw or phalangeal impressions" (Lull).

The peculiarity of this genus which gives it its name is that the impressions of manus and pes point in opposite directions. Other than this the tracks resemble most closely those of *Sustenodactylus.*

Antipus flexiloquus E. Hitchcock

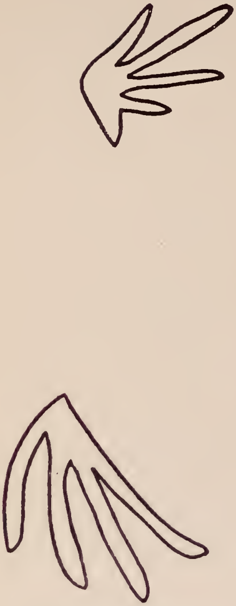


Fig. 117.—*Antipus flexiloquus*. Nat. size. After Hitchcock.

E. Hitchcock 1858, p. 115, pl. 20, fig. 10.
Lull 1904 A, p. 536.

Type specimen, Cat. No. 41/52, Amherst collection, from Turners Falls, Mass., the only recorded locality.

Specific Characters.—Manus: Length of impression, 23 mm.; its breadth, 21 mm. Divarication of lateral digits, 131°.

Pes: Length of digit I (the outermost as the impression lies), 18 mm.; II, 20 mm.; III, 20 mm.; IV, 19 mm.; between lateral tips, 25 mm. Length of foot, 29 mm. Divarication of lateral digits, 60°.

Length of step, 38 to 84 mm. Width of trackway, 127 mm.

Genus **Sustenodactylus** Lull

Stenodactylus E. Hitchcock 1858, p. 116.
Lull 1904 A, p. 537 (for *Stenodactylus* preoccupied).

Generic Characters.—"Quadrupedal, digitigrade; pentadactyl manus and pes. Digits extremely slender and tapering, without claws or pads. Pes about twice the size of the manus" (Lull).

Sustenodactylus curvatus (E. Hitchcock)

Stenodactylus curvatus E. Hitchcock 1858, p. 116, pl. 20, fig. 11; pl. 34, fig. 3.
Lull 1904 A, p. 537.

Type specimen, Cat. No. 34/43, Amherst collection, from Turners Falls, Mass., the only recorded locality.

Specific Characters.—Manus: Length of digit I, 6 mm.; II, 7 mm.; III, 13 mm.; IV, 14 mm.; V, 3 mm. Divarication of lateral digits, 180°.

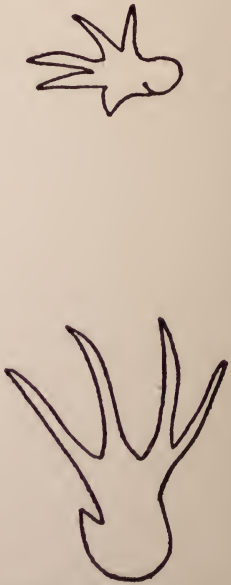


Fig. 118.—*Sustenodactylus curvatus*. Nat. size. Original.

Pes: Length of digit I, 18 mm.; II, 20 mm.; III, 26 mm.; IV, 22 mm.; V, 6.5 mm.; of foot, 26 mm. Divarication of the lateral digits, 70°.

Length of step, 90 mm. Width of trackway, 64 mm.

Genus **Isocampe** E. Hitchcock

E. Hitchcock 1858, p. 119.

Lull 1904 A, p. 537.

Generic Characters.— "Quadrupedal; manus and pes of unequal size, the former tetradactylous, possibly pentadactylous; the latter tetradactylous. Digits of pes nearly parallel and curved toward the median line; those of the manus nearly straight, divergent. No pads nor claws. Digitigrade; with a caudal trace. A short-limbed, broad-bodied form" (Lull).

Isocampe strata E. Hitchcock

E. Hitchcock 1858, p. 120, pl. 20, fig. 5; pl. 36, fig. 5.

Lull 1904 A, p. 537.

Type specimens, Cat. No. 40/62, from Turners Falls, Mass., and No. 26/4, from Middletown, Conn., both in the Amherst collection. No other localities recorded.

Specific Characters. — Manus: Length of digit I, 28 mm.; II, 43 mm.; III, 30 mm.; IV, 28 mm. Divarication of digits I and IV, 35°.

Pes: Length of digit I, 42 mm.; II, 51 mm.; III, 58 mm.; IV, 55 mm. Digits parallel.

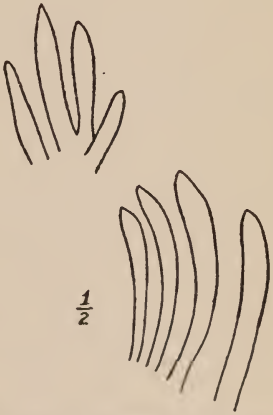


Fig. 119.— *Isocampe strata.* One-half nat. size. After Hitchcock.

Length of step, 161 mm. Width of trackway, 78 mm.

Genus **Shepardia** E. Hitchcock

E. Hitchcock 1858, p. 131.

Lull 1904 A, p. 538.

Generic Characters. — Quadrupedal, digitigrade, feet nearly equal in size. Manus pentadactylous, pes clawed, tetradactylous, with a vestigial fifth digit.

Shepardia palmipes E. Hitchcock

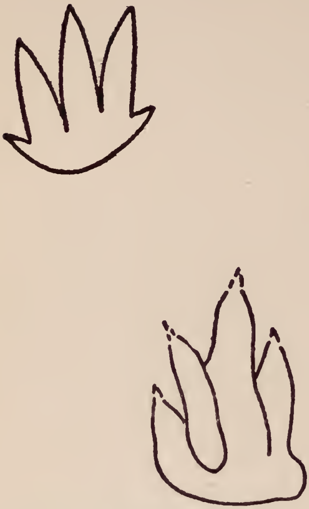


FIG. 120.—*Shepardia palmipes.* Nat. size. Original.

E. Hitchcock 1858, p. 131, pl. 24, fig. 2.

Lull 1904 A, p. 538.

Type specimen, Cat. No. 1413, Shepard collection, at Amherst College, from below the cataract at Turners Falls, Mass., the only recorded locality.

Specific Characters. — Manus: Length of digit I, 10 mm.; II, 18 mm.; III, 23 mm.; IV, 26 mm.; V, 10 mm.; between lateral tips, 18 mm. Divarication of digits I and II, 30°; II and III, 25°; III and IV, 20°; IV and V, 30°.

Pes: Length of digit I, 13 mm.; II, 25 mm.; III, 30 mm.; IV, 23 mm.; between lateral tips, 22 mm.; length of foot, 30 mm.

Genus **Comptichnus** E. Hitchcock

E. Hitchcock 1865, p. 9.

Lull 1904 A, p. 538.

Generic Characters. — "Quadrupedal, tetradactylous, digitigrade. Digits of the pes broad, showing neither claw nor phalangeal impressions, those of the manus making peculiar oval marks" (Lull).

Comptichnus obesus E. Hitchcock

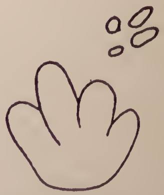


FIG. 121.—*Comptichnus obesus.* Nat. size. Original.

E. Hitchcock 1865, p. 9, pl. 5, fig. 4; pl. 18, fig. 6.

Lull 1904 A, p. 538.

Type specimen, Cat. No. 55/5, Amherst collection, from the Lily Pond, Turners Falls, Mass. No other recorded locality.

Specific Characters. — Manus: Four oval impressions, three slightly radiating in front, one behind. Length of tracks, 8 mm.

Pes: Length of digit I, 6.5 mm.; II, 9 mm.; III, 13 mm.; IV, 10 mm.; of foot, 15 mm. Divarication of digits I and II, 28°; II and III, 20°; III and IV, 14°.

Length of step, 65 mm. Width of trackway, 38 mm.

Genus **Arachnichnus** E. Hitchcock

E. Hitchcock 1858, p. 117.

Lull 1904 A, p. 538.

Generic Characters. — Quadrupedal, plantigrade. Pes tetradactylous, with vestigial fifth digit; the impression of the manus tetradactylous also. Limbs moderately long; body wide.

Arachnichnus dehiscens E. Hitchcock

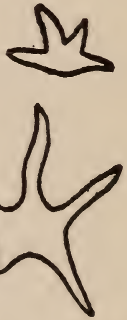


Fig. 122. — *Arachnichnus dehiscens.* Nat. size. Original.

E. Hitchcock 1858, p. 117, pl. 20, figs. 12, 13; pl. 37, fig. 2; 1865, pl. 17, fig 2.

Lull 1904 A, p. 539.

Type specimen, Cat. No. 51/18, Amherst collection, from the Lily Pond, Turners Falls, Mass.

Specific Characters. — Manus: Length, 9 mm.; breadth, 13 mm. Divarication of lateral digits, 180°.

Pes: Length of digit I, 10 mm.; II, 11 mm.; III, 14 mm.; IV, 7.5 mm.; between the lateral tips, 19 mm.; length of foot, 28 mm. Divarication of digits II and IV, 85°.

Length of step, 76 to 114 mm. Width of trackway, 76 mm.

Localities. — Turners Falls and Lily Pond, Mass.

VERTEBRATA of Doubtful Class

Genus **Triænopus** E. Hitchcock

E. Hitchcock 1845, p. 24; 1848, p. 202; 1858, p. 111.

Lull 1904 A, p. 539.

Generic Characters. — "Quadrupedal, tetradactylous on both fore and hind feet. Toes slender and long; three directed forward with small divarication. Fourth toe coming out near the extremity of a long heel" (Hitchcock).

A common Wethersfield shale genus, but so obscure a track that the manus cannot be distinguished from the pes, if such they are.

Triænopus baileyi E. Hitchcock

Sauroidichnites baileyi E. Hitchcock 1841, p. 480, pl. 32, figs. 8-10.

Sauroidichnites emmonsii E. Hitchcock 1841, p. 479, pl. 30, fig. 4; pl. 31, figs. 5, 6.

Triænopus baileyanus E. Hitchcock 1845, p. 24; 1848, p. 203, pl. 10, fig. 4.

Triænopus emmonsianus E. Hitchcock 1845, p. 24; 1848, p. 204, pl. 10, fig. 5.

Triænopus leptodactylus 1858, p. 111, pl. 19, figs. 1-9; pl. 20, figs. 1-3; pl. 45, fig. 8; pl. 52, fig. 1.

Triænopus baileyanus Lull 1904 A, p. 539.

Type specimen, Cat. No. 31/27, Amherst collection, on red shale, from Wethersfield, Conn.

Specific Characters. — Manus: Length of digit II, 38 to 51 mm.; III, 60 to 80 mm.; IV, 38 to 55 mm.; of hand, 70 to 100 mm.; between lateral tips, 38 to 51 mm. Divarication of the front lateral toes, 50°.

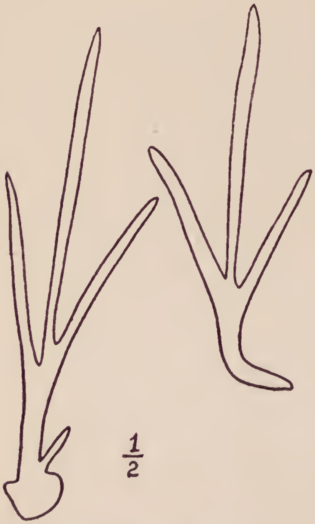


FIG. 123.— *Triænopus baileyi.* One-half nat. size. After Hitchcock.

Pes: Length of digit II, 40 to 56 mm.; III, 63 to 90 mm.; IV, 50 to 63 mm.; of heel, 35 to 50 mm.; of foot, 100 to 125 mm. Divarication of the lateral toes, 35° to 40°.

Length of step, about 180 mm. Width of trackway, 63 mm.

Genus **Toxichnus** E. Hitchcock

E. Hitchcock 1865, p. 12.

Lull 1904 A, p. 541.

Generic Characters. — ? Quadrupedal. "Both feet. — Leptodactylous, tetradactylous, digitigrade, toes all gracefully curved inward, except the innermost, which is nearly straight" (Hitchcock).

This genus is not well defined, as it is known from but two specimens, Cat. Nos. 55/3, 55/33, of the Amherst collection, the first from the north bank below Turners Falls, Mass.; the second from Howland's farm, Turners Falls; to which must be added a third, Cat. No. 2122 and its counterpart in the Yale collection, from Gill, Mass.

Toxichnus inæqualis E. Hitchcock

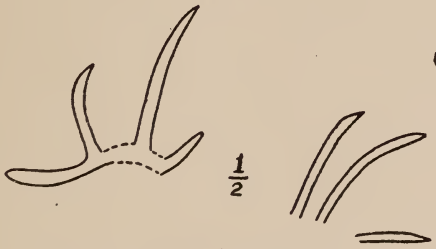


FIG. 124. — *Toxichnus inæqualis*, One-half nat. size. After Hitchcock.

E. Hitchcock 1865, p. 12, pl. 5, fig. 5.

Lull 1904 A, p. 542.

Type specimens, the Amherst ones enumerated above.

Specific Characters. — Manus: Length of digit II, 20 mm.; III, 33 mm.; IV, 28 mm.; of hand, 41 mm.

Pes: Length of digit I, 8 mm.; II, 43 mm.; III, 34 mm.; IV, 25 mm.; of foot, 43 mm.

Length of step, 120 mm.

The Yale specimen seems to impress the hind foot only, and the true nature of the track is evidently obscured by mud flowage. It seems, however, to represent another species, but I shall not venture to describe it.

Ammopus Marsh

Marsh 1896 B, pl. 5, fig. 1 (figure, but no description).

Generic Characters. — Quadrupedal, digitigrade, feet unequal in size; manus pentadactyl, pes tetradactyl, with rounded heel. Digits all curved but without separate claw or phalangeal pad impressions. Stride short and trackway broad.

Ammopus marshi, sp. nov.

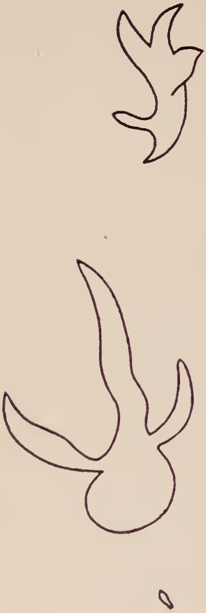


Fig. 125.—*Ammopus marshi.* Nat. size. Original.

Type specimen, Cat. No. 2040 and its counterpart, Yale collection, from the ferry above Turners Falls, Mass., the only known locality.

Specific Characters. — Manus: Length of impression, 20 to 21 mm.; its breadth, 18 mm.

Pes: Digit I, claw just touching; length of digit II, 12 mm.; III, 26.5 mm.; IV, 16 mm.; of foot, 47 mm.

Length of step, 75 mm. Width of trackway, about 90 mm.

This footprint, if the pes alone impressed, might readily resemble the Yale *Toxichnus* specimen of which I have spoken were the impression a little more obscure. It differs therefrom, however, in that in *Ammopus* the two inner anterior digits curve outward, in *Toxichnus* sp. the two outer curve inward. This species is dedicated to Professor O. C. Marsh, who named and figured the genus though without description.

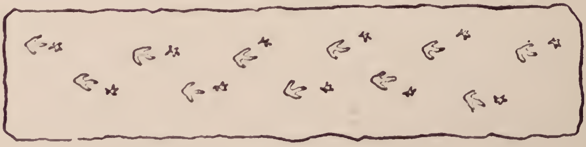


Fig. 126.—Footprints of *Ammopus marshi.* One-twelfth nat. size. After Marsh.

A few other genera of very doubtful validity I shall omit from this enumeration.

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